Department of Primary Industries
Department of Regional NSW

NSW GOVERNMENT

Orchard plant protection guide for deciduous fruits in NSW 2023–24

NSW DPI MANAGEMENT GUIDE

Kevin Dodds and Jessica Fearnley

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Orchard plant protection guide for deciduous fruits in NSW 2023–24

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Disclaimer
The information contained in this publication is based on knowledge and understanding at the time of writing (August 2023). However, because of advances in knowledge, users are reminded of the need to ensure that the information upon which they rely is up to date and to check the currency of the information with the appropriate officer of NSW Department of Primary Industries or the user's independent advisor.

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Permits
The chemical use patterns quoted in this publication that are approved under permits issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) are in force at the time the publication was prepared. Persons wishing to use a chemical in a manner approved under permit should obtain a copy of the relevant permit and approved use pattern from the supplier of the product at point of sale and must read all the details, conditions and limitations relevant to that permit, and must comply with the details, conditions and limitations prior to and during use.

Acknowledgements
We thank the officers of the NSW DPI and other organisations who have helped to revise this issue of the guide. We would also like to thank Trevor Klein and Aphrika Gregson, Farm Chemicals Officer, for reviewing the pesticide recommendations, Dr Amanda Warren-Smith for her guidance and editorial skills. Once again, agricultural chemical companies have provided information on their products and helpful suggestions, and we thank them for their involvement and interest.

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Advertising
If you wish to advertise within this guide and expose your product or service directly to deciduous fruit producer groups and other stakeholders, please contact Dr Amanda Warren-Smith at amanda.warren-smith@dpi.nsw.gov.au or phone 0419 235 785.

Contents

About this guide

The 2023–24 edition of the *Orchard plant protection guide for deciduous fruits 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

Dr Allen Benter and Jessica Fearnley outline the NSW DPI Climate-Smart Pilots project investigating protected cropping methods for cherries at Orange, NSW. This initial report (page 6) describes the trial and some preliminary results for temperature, humidity, wind speed and fruit quality attributes of cherries under the protective covers.

Jess Fearnley provides an outline of the new NSW DPI-led Hort Innovation project 'Extension and communication for the Australian cherry industry (CY22002)' on page 10.

The NSW seasonal climate outlook for August 2023 indicates an increased likelihood of warmer than average temperatures for most of NSW from September to November 2023. There is an increased likelihood of rainfall being below average to well below average for most of NSW for the same period. This is due to the combined effects of a positive Indian Ocean Dipole (IOD) and El Niño. This edition of the guide includes a timely feature article by Kevin Dodds, Jess Fearnley and Jeremy Bright entitled 'Water and crop management strategies for temperate fruit orchards during drought' on page 14.

Reflecting on elevated fungal disease levels in NSW orchards following several seasons of wet conditions in the key temperate fruit regions, Jess Fearnley and Kevin Dodds have prepared an article entitled 'Spotlight on apple scab' (page 18) which focuses on seasonal conditions that have favoured the disease and some important steps to reducing disease pressure and gaining control of the primary infection phase of this important apple and pear disease.

The authors would like to acknowledge Dr Sally Bound of the Tasmanian Institute for Agriculture for her contribution to the section Chemical thinners for pome and stone fruits on page 134.

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, see the NSW DPI website (https://www.dpi.nsw.gov.au/agriculture/horticulture/pests-diseases-hort/information-for-multiple-crops/orchard-plant-protection-guide).

Additional copies can be obtained through NSW DPI Tocal bookshop (https://shop.regional.nsw.gov.au/collections/horticulture).

How to use this guide

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

Step 1: go to Table 2 or Table 3 and find the pest or disease you are interested in. These are listed alphabetically under 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 your pest or disease.

Alternatively, you can visit the contents table (page iii) 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 major pests and diseases through responsible pesticide use (page 147). Pesticide use can be moderated even further through good orchard management and implementing practices such as integrated pest, disease and weed management (IPDWM).

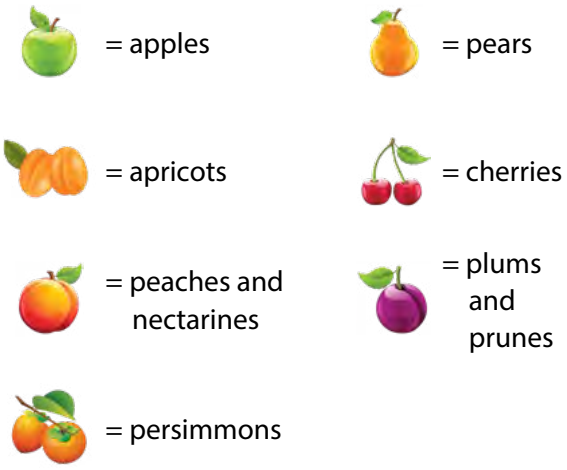

Figure 1. The icons are used to identify the crops covered in this guide:

Weather influences the pests and diseases that affect 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 is the key.

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 and managing overhead irrigation to prevent creating favourable conditions for disease infections unless the reasons against it are compelling (i.e. frost management or mitigating heat stress).
- Practising good hygiene, including appropriate disposal 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 the winter.
- Destroying feral fruit trees and neglected orchards.
- Encouraging predatory and parasitic insects by not using disruptive chemicals.

The sections on pests (page 29) and diseases (page 98) provide specific details on weather conducive to pest or disease outbreaks and on non-pesticide management options where applicable. Orchardists should always keep in mind that the exclusive use of pesticides or alternative management will rarely produce satisfactory fruit quality. Each management strategy supplements the other.

Protected cropping in cherries

Dr Allen Benter, Technical Specialist – Digital Agriculture
Jessica Fearnley, Development Officer – Temperate Fruits

Are protective covers right for your orchard?
How does protected cropping change an orchard's climate?
What are the benefits, and what are the costs?

As the climate becomes more unpredictable and extreme weather becomes more common, growers are testing new technologies to improve their orchard's resilience to a changing climate. Protective rain covers are an option for growers to protect their crops from rain and hail. NSW DPI has been building a large body of research for using protective rain covers for cherry production, including social and behavioural surveys, vulnerability assessments, research trials and economic analyses.

Cherry production is expanding quickly into new geographic regions in NSW due to recent growth in demand from overseas markets for high-quality cherries (Figure 2). Despite this growth, cherry production is challenged by adverse weather conditions that affect yield and quality each year. Rainfall at harvest can induce cherry cracking (Figure 3), downgrading fruit to being unsaleable. Throughout Australia, agricultural growing regions can expect changes to climatic conditions, including increases in global temperature and sea level, heavy rainfall becoming more intense and fire seasons becoming longer.

Retractable rain covers deployed to shield the fruit from rain can be highly effective at minimising cherry cracking, but they are expensive and labour-intensive to deploy each season. Automated systems can reduce this labour but add to the costs. Protective rain cover use in cherry orchards has not been widely adopted in NSW for various reasons, including installation cost, perceived negative effect on fruit firmness, increased humidity and implications on disease conditions and the extra time needed to manage the covers.

The trial

NSW DPI's Climate-Smart Pilots team used digital sensors on a commercial orchard to monitor the influence of protective covers during the 2022–23 growing season. Digital sensors were installed (Table 1) to measure temperature and humidity (at the middle and top of the trees) and wind speed (within the row). Soil moisture sensors were also installed, but these data have not been included in these results. An automatic weather station was installed on-site, approximately 300 m from the areas being studied.

The orchard in Nashdale (near Orange) previously had rain covers over part of the orchard, enabling a comparison of environmental conditions between covered and uncovered trees and between 2 varieties.

Figure 2. Sweet Georgia cherries harvested at the Nashdale research site.

Figure 3. Rain during harvest can cause cherry cracking or splitting.

Table 1. A list of sensors deployed at the Orange trial site.

Sensor	Use	Type used
Anemometer (Figure 4)	Measure wind speed and wind direction	Davis Vantage Pro
Temperature and humidity sensor (Figure 5)	Measure changes in temperature and humidity	Netvox R718A
Soil moisture probe (Figure 6)	Measure soil moisture and soil temperature at one depth	Meter Teros-12
Weather station (Figure 7)	Measures 12 weather variables including air temperature, relative humidity, vapour pressure, barometric pressure, wind speed and direction, solar radiation, precipitation, lightning	Meter Atmos-41
Network gateway (Figure 8)	Connects sensors to a common panel and sends data to the grower	LoRaWan Gateway (MultiTech Conduit IP67)

Figure 4. Davis Vantage Pro Anemometer installed at the Nashdale trial site.

Figure 5. Netvox R718A temperature and humidity sensor installed at the Nashdale trial site.

Figure 6. Meter Teros-12 soil moisture probe installed at the Nashdale trial site.

Figure 7. A Meter Atmos-41 weather station was used to collect climate data.

An important factor for all field trials is their exposure to environmental conditions. The weather was unfavourable for cherry production at the start of the season but improved towards the end of the first year of the trial.

- Conditions were cool and wet during pollination, resulting in variable fruit set.
- Above average rainfall during November and below average temperatures in November and December delayed harvest for each variety for up to 4 weeks.
- Average temperatures increased after the Christmas period.

The climatic environment outside and inside the protective covers were recorded by the sensors.

Figure 8. LoRaWan Gateway (MultiTech Conduit IP67) installed at the Nashdale trial site.

Results

Preliminary results show that protective rain covers:

- did not influence average temperatures under the covers
- lowered maximum temperatures by up to 4 °C
- increased average humidity by 6%
- lowered maximum wind speeds by 9.4 km/h, which was a significant reduction.

The protective covers were used during growth and harvest. Initial harvest results indicate increased cherry quality, with larger, firmer cherries from under the nets than outside the nets (Figure 9). Additionally, a greater volume of cherries was suitable for picking from under the covers as fewer were culled.

Figure 9. Lapin harvest from outside of the protective covers. Note the splitting and variability in ripeness.

It is important to note that this trial was at one orchard for one season. While initial results are encouraging, they also show that longer running trials in more geographically diverse locations with different types of covers (both rain and shade) are needed. How the covers mitigate climate variables such as wind speed and maximum temperature in cherry-growing areas will be valuable

information for the industry. Further research is also needed to investigate the modified farming practices required with using the covers to optimise their performance.

Being able to make informed decisions based on data and local research will increase the adoption of protective covers in the NSW cherry industry. Further work into the economic viability to combine with the results of this trial will make this more effective.

Next steps

NSW DPI is committed to providing information and decision support tools for NSW cherry growers. Continuing to explore the use of protective covers in cherry orchards is one such project. In the coming seasons, we hope to focus on:

- adding more locations and types of net to create more datasets
- investigating how the timing of management activities might influence the surrounding climate under the covers
- measuring how irrigation might affect the climate under the covers, and if this might affect water use
- projecting how future climate changes might influence the feasibility of using protective covers in cherry orchards
- providing an economic analysis comparing different scenarios and cover options.

A more detailed analysis of results and fruit quality data, along with future results, can be found at the NSW DPI Climate Research website (https://www.dpi.nsw.gov.au/dpi/climate/digital-agriculture/digital-agriculture-research2/horticulture-research/protected-cropping).

If you would like to be involved in this trial, or you are interested in learning more, please contact Jessica Fearnley, Development Officer – Temperate Fruits, on 0437 284 010 or jessica.fearnley@dpi.nsw.gov.au

Extension and communication for the Australian cherry industry

Jess Fearnley, NSW DPI

A new Hort Innovation funded project, using the cherry research and development levy and contributions from the Australian Government, led by NSW DPI, will increase communication and extension activities for the Australian cherry industry. By supplying timely industry news and R&D updates to Australian cherry growers, we aim to enhance grower and industry engagement.

Building a capable and innovative culture through extension was identified as important to improve the industry's networks and collaboration in the Hort Innovation Cherry Industry's Strategic Investment Plan (2022–2026). This will strengthen the industry and create opportunities to enhance access to both existing and future domestic and international markets. Adopting improved practices will increase efficiencies and develop resilience in the industry.

As part of the project, growers can expect to see:

- Monthly newsletters with information about events, R&D, seasonal updates, and other updates relevant to the cherry industry.
- Case studies on topics such as managing pests and diseases, young trees, crop load and different technology and innovations for your orchard.
- A regular podcast with industry leaders and international guests.
- Technical and informative videos on different trials, management practices and industry updates.
- Fact sheets on integrated pest and disease management (IPDM), crop nutrition and technology.
- Field days in growing regions to showcase demonstration trials and presentations from industry leaders.
- Webinars and workshops on topics identified as valuable to the industry.

The project will also include a Regional Growers Program, which will include grower groups that will run demonstration trials and discussion groups on various industry challenges. The Regional Delivery Partners are Cherry Growers Australia, Fruit Growers Tasmania, the Victorian Cherry Association and South Australian Research and Development Corporation, will facilitate these and the results will be disseminated through the national cherry communication platform. All content will be available to all levy-funded cherry growers across Australia.

For more information, or to get involved with one of the Regional Grower Groups or to help develop content, please contact the National Cherry Extension Manager, Jess Fearnley on 0437 284 010 or jessica.fearnley@dpi.nsw.gov.au.

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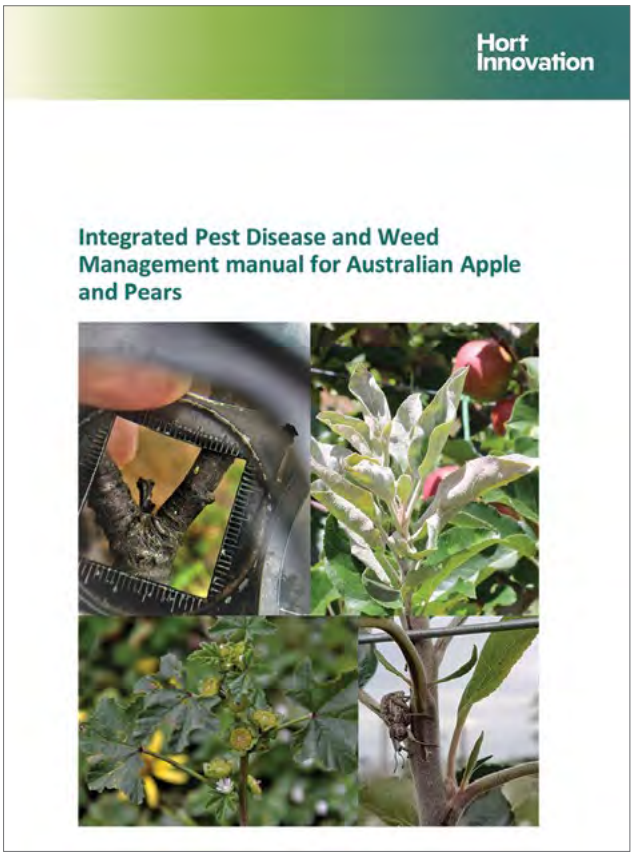


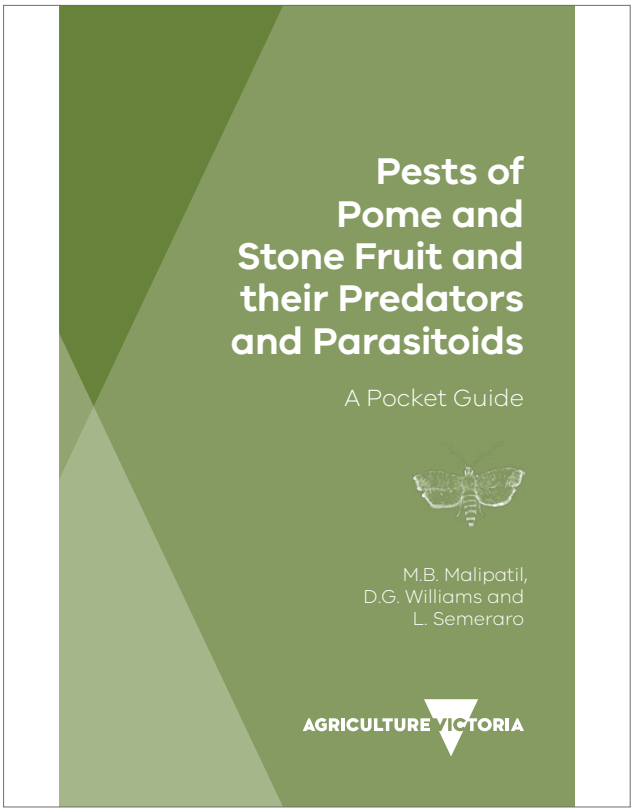
The revised 2nd edition, published May 2021 is available from extensionAUS (https://extensionaus.com.au/ozapplepearipdm/ipdm-manual-for-apples-and-pears/).

The manual includes:

- introduction to IPDM
- developing an IPDM plan
- key pests and diseases, their activity periods and monitoring methods
- biosecurity and potential incursions of new pests
- integrated weed management
- pesticides and the Australian apple and pear industry
- pest and disease fact sheets.

This Manual is an output of 'An integrated pest, disease and weed management program for the Australian apple and pear industry' (AP16007) funded by Hort Innovation, using the apple and pear industry research and development levy, contributions from the Australian Government and co-investment from New South Wales Department of Primary Industries. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture

The popular AgVic Pocket Guide



has been published as an e-book on the site, you can save it to your phone as a handy tool in Books, as a pdf, or save as a favourite in your browser (https://extensionaus.com.au/ozapplepearipdm/draft_useful-tool-pests-pocket-guide/).

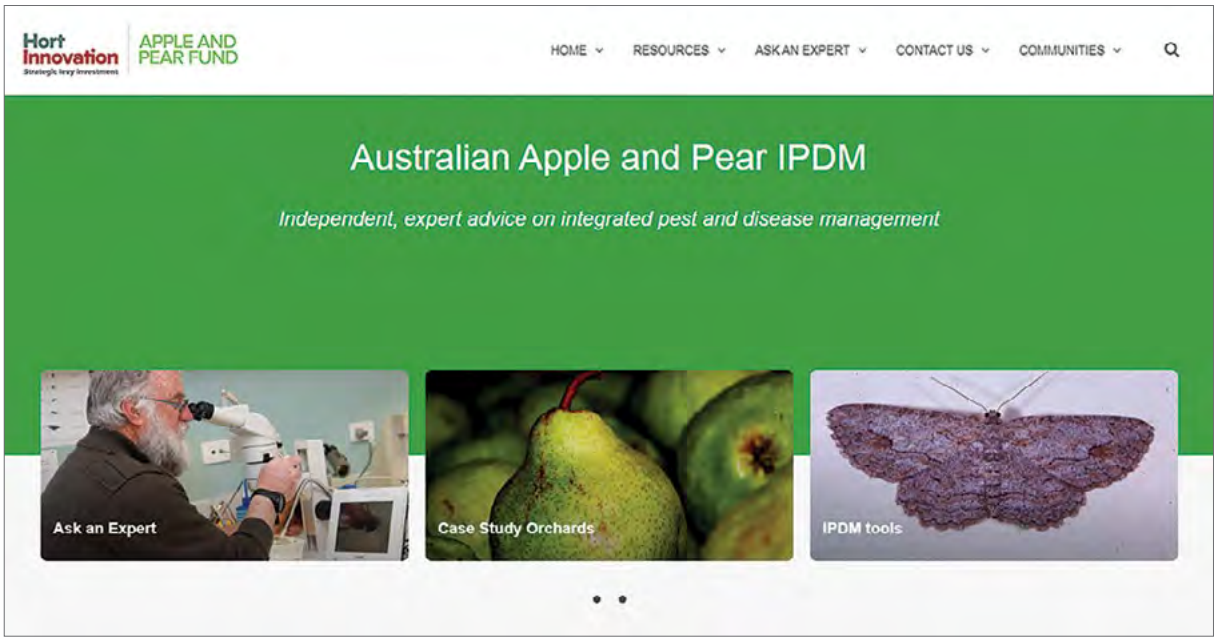
Published in May 2019, by David Williams (Agriculture Victoria).

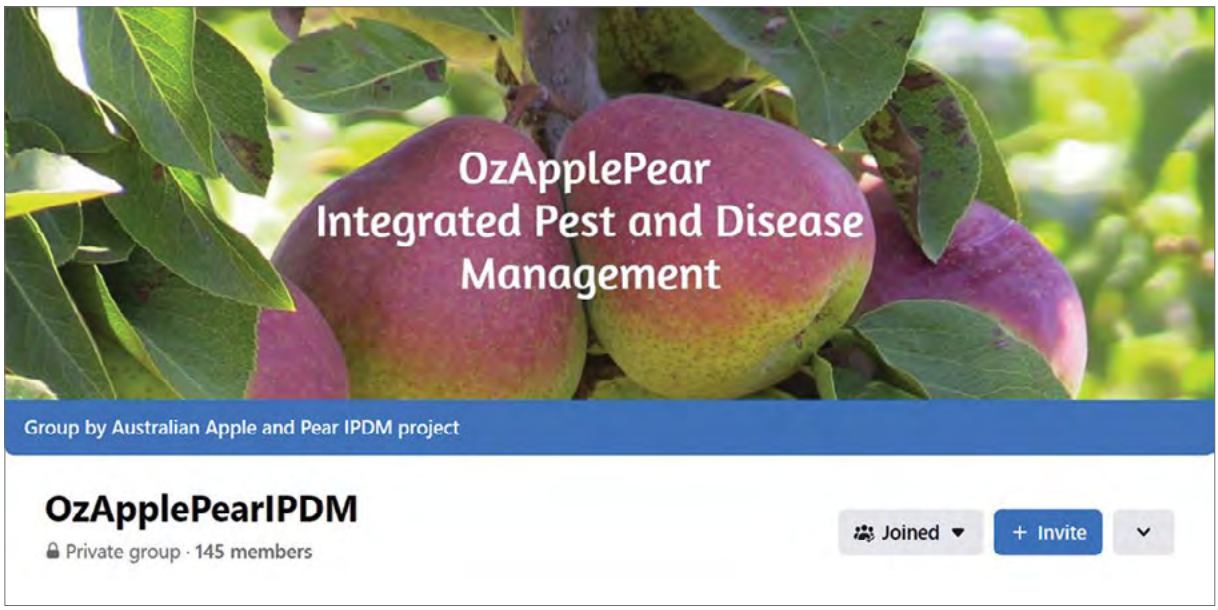
The Australian apple and pear IPDM webpage and Facebook page

This website (https://extensionaus.com.au/ozapplepearipdm/home) provides independent, expert advice on integrated pest and disease management, including:

- 'Ask the expert': growers or service providers can ask IPDM questions or upload photos to identify a pest or disease
- IPDM tools and resources
- case study orchards implementing IPDM with an expert
- timely warnings on outbreaks
- seasonal reminders on management strategies

Join the Facebook group (https://www.facebook.com/groups/579194849206452/).





Hort Innovation APPLE AND PEAR FUND

This project has been funded by Hort Innovation using the apple and pear research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

Water and crop management strategies for temperate fruit orchards during drought

Kevin Dodds, Jessica Fearnley and Jeremy Bright (NSW DPI)

Water is a critical input in any fruit production system. It plays a vital role in plant processes including nutrient transport, cell turgor and growth, photosynthesis and temperature regulation. Modern temperate fruit orchards use irrigation systems to ensure adequate water supply to the soil and crop as required. These systems rely on stored or pumped water being available. In severe drought, on-farm water resources can reach critically low levels, placing crop and tree performance at risk.

Efficient water use in the orchard is always a high priority, but even more so when rainfall and water resources reach potentially limiting levels. During a drought, orchardists must implement all possible management strategies to maximise water use efficiency and minimise the negative effects of reduced water on crops and trees. Some strategies growers can consider are included here.

Water management strategies

Pre-season planning and irrigation system checks

A pre-season water plan might include estimating the water requirements per block, expected irrigation period (e.g. October–April), scheduling, frequency, run times and prioritising blocks if water becomes limited. Planning ahead for blocks that will be placed on tree survival irrigation will be easier than during the season.

System checking usually involves a test run before the irrigation season to assess system output and identify any problems such as breakages, blockages or off-target water losses.

Plan well ahead for new orchard blocks and aim to have irrigation water available to young trees from the day of planting.

Prioritise young blocks

Newer blocks (Figure 10) are often the most valuable because they contain high value varieties and represent the future of the orchard. Water stress on young developing trees can result in stunted growth and poor block establishment.

When developing an irrigation plan, prioritise young blocks over older blocks and those that do not perform well. In extreme circumstances, you might need to walk away from some blocks and focus on those with the highest known value and returns.

Another option could be to chemically remove the crop early in the season to reduce the risks associated with normal cropping and stress.

Drought can also be a strong motivator to remove those old orchard blocks that have been under-performing for some time.

Figure 10. Young orchards are a high priority for irrigation in drought because of their shallow root systems and high value.

Soil moisture monitoring

Using irrigation water efficiently during water shortages is paramount. Monitoring the fate of water applied to the soil is the only way to properly understand if it is meeting crop needs while not resulting in waste and nutrient loss via leaching. Efficiently using irrigation water requires knowing how the water applied affects soil moisture levels and how far the moisture travels in the soil.

There are 2 main types of soil moisture probes: those measuring soil water tension (i.e. tensiometers or gypsum blocks; Figure 11) and those measuring volumetric soil moisture (i.e. capacitance probes; Figure 12).

Tensiometers measure how hard a plant must work to extract the available moisture at a given time, while capacitance probes measure total water in the soil and indicate how this changes over time. Typically, tensiometer probes have a single sensor, meaning multiple probes are required to track soil moisture at various depths. Capacitance probes usually include sensors at multiple depths built into one probe.

Figure 11. A gypsum block probe.

Estimating crop water use

A crop water budget provides a method for estimating crop water needs based on crop evapotranspiration (ETc), irrigation efficiency, rainfall, soil type and crop coefficient (Kc). The publication *Guide to best practice in water management: orchard crops* (2009) by Dr Anne-Maree Boland is a useful document that covers all aspects of temperate tree fruit irrigation including estimating crop water needs for a range of crops. This document is available (along with many other useful publications) via the Apple and Pear Australia Limited Future Orchards Library (https://apal.org.au/programs/future-orchards/future-orchards-library/).

Water wisely

Wise water use includes practices such as avoiding irrigating during the hottest part of the day (if possible). This will reduce losses due to surface evaporation. Depending on the irrigation system capacity, this might not be practical as many systems need to be run almost constantly in summer to cycle around the blocks in a 24 hour period. In these situations, consider scheduling daytime irrigations on blocks that are least likely to be affected by evaporation. For example, those covered with protective netting and those in areas less exposed to drying winds. Leave the exposed and windy sites for night-time irrigating.

Always aim to use shorter, more frequent irrigation intervals (i.e. pulse irrigation). This helps to keep water and fertigated nutrients in the active root zone and is less likely to result in leaching. This is particularly important in shallow-rooted dwarf orchards on drip irrigation, as the main root systems are usually quite shallow and can be concentrated around dripper zones.

Figure 12. A capacitance probe.

Take advantage of stone fruit growth patterns

Apple and pear fruit grow at a fairly constant rate throughout the season and therefore generally require adequate soil moisture throughout the fruit growing phase. Conversely, stone fruits grow rapidly after fruit set and in the lead-up to harvest, but in the middle of the season (when the pit or stone is hardening), fruit diameter growth is minimal and any water applied is more likely to result in vegetative shoot growth. The pit hardening period in stone fruits is an opportunity to reduce irrigation without negatively affecting fruit growth or tree health. Regularly monitoring fruit growth can help to identify when pit hardening starts and finishes.

Reducing moisture loss

Ensuring good weed control, particularly near the effective root zone, will minimise moisture losses due to competition. Weed control can be physical or chemical; see Managing weeds on page 139.

Applying organic mulches (Figure 13) where practical will help reduce evaporation, retain soil moisture and increase soil carbon, thus improving long-term soil water holding capacity and general soil health. Mulches can provide the added benefit of suppressing weeds, provided it is deep enough to block out light and prevent seed germination and growth.

Studies show that protective hail netting reduces solar radiation, evaporation and crop water requirements in orchards. Monitoring soil moisture in netted and un-netted blocks might help growers take advantage of reduced water demand in netted blocks.

Figure 13. Organic mulches can help retain soil moisture in the profile by reducing evaporation and competition from weeds.

Crop and tree management strategies

Start crop load planning in winter

Have a plan for the optimum fruit size (weight) and number per tree that will deliver the desired yield per hectare. The target number of fruit per tree can then be used to guide winter pruning. Removing excess fruit buds at pruning (either by snipping or spur removal) will reduce the spring bud load and potential hand-thinning costs. Note: when counting buds to retain, it is important (particularly in varieties that are prone to biennial bearing) to plan to retain sufficient buds so that some will be free of fruit and resting in the current season to develop buds for the next season.

In drought years, consider reducing the number of fruit buds retained at pruning. This will take some pressure off the primary and secondary thinning programs in spring.

Adjust thinning regimes

During drought, aim to reduce crop load early and by more than usual. Plan for aggressive blossom thinning and early fruit thinning. Also be prepared to sacrifice some yield to achieve the desired fruit quality and average size.

Be prepared to carry out additional hand fruit thinning if required (Figure 14). Use fruit size monitoring and fruit size curves (trend lines) to help decide when additional fruit thinning is needed.

In apples, complete crop removal is an option when the block is to receive tree maintenance irrigations only. Certain registered products with the active constituent ethephon include label recommendations for aiding complete removal of apple fruit.

Monitor fruit size

Establish fruit size monitoring plots in each orchard block and measure the same 20 fruit per block weekly, starting when fruit reach 20 mm in diameter and continuing until harvest. Comparing the weekly average fruit growth rate can help identify any slow-down in growth that might be due to water stress and/or over-cropping. Comparing the seasonal fruit growth curve with past seasons can also help identify if the crop is on track to reach the target fruit size. Accurate fruit size monitoring involves returning to the same fruit each week and recording the growth rate and progressive fruit size. The online program OrchardNet (https://www.hortwatch.com/orchardnet/) has a good tool for recording and graphing fruit size and comparing seasons based on growth from full bloom. OrchardNet also includes target fruit growth trend lines for the key varieties. An excel spreadsheet could also be used to track fruit growth data.

Figure 14. Fruit thinning programs might need to be adjusted to ensure the target fruit size is achieved. It might be necessary to accept a lower overall yield during drought.

Re-think the timing of pruning

Historically, most temperate fruit trees are pruned in winter. This typically results in a strong spring growth response, which creates a high demand for water and nutrients in the early part of the growing season. Conversely, summer pruning will suppress vigour and reduce canopy area, resulting in more efficient use of available water and nutrient resources to help support satisfactory fruit growth.

Summary

Water is a critical input in any fruit production system, but especially during drought. Water management strategies including pre-season planning, prioritising young blocks, monitoring soil moisture, estimating crop water use, watering wisely, taking advantage of stone fruit growth patterns and reducing moisture loss can be implemented to help. Additionally, crop and tree management strategies such as planning in winter for crop loads, adjusting thinning regimes, monitoring fruit size and considering different times to prune can also help with efficient water use in orchards.

Useful resources

Anon (2020) Dry season information for stone fruit, Agriculture Victoria, https://agriculture.vic.gov.au/crops-and-horticulture/fruit-and-nuts/fruit/dry-season-management-stone-fruit#:~:text=Dry%20season%20management%20%E2%80%94%20stone%20fruit%201%20Managing,4%20Irrigation%20strategies%20in%20a%20dry%20season%20

Boland AM (2009) Guide to best practice in water management: orchard crops, APAL, https://apal.org.au/wp-content/uploads/2019/09/fo-ow-handout-09-sept-best-practice-water-mgmt-boland.pdf

James P (2011) Australian cherry production guide, https://www.cherrygrowers.org.au/assets/australian_cherry_production_guide.pdf

Future Orchards® library, APAL, https://apal.org.au/programs/future-orchards/archive-library/

Information for drought-affected farmers

Department of Agriculture, http://www.agriculture.gov.au/ag-farm-food/drought

DroughtHub, https://www.dpi.nsw.gov.au/climate-and-emergencies/droughthub

Spotlight on apple scab

Jessica Fearnley and Kevin Dodds

Apple scab is caused by a fungal pathogen (*Venturia inaequalis*) that infects apple leaves (Figure 15) and fruit (Figure 16) when airborne spores land on an unprotected surface and germinate following a period of wetness and favourable temperatures. If the early-season (primary) infection phase is not effectively controlled, the disease potential will continue into summer and autumn (secondary infection phase) with potentially devastating effects on the crop.

Figure 15. Primary apple scab infection on leaves.

Figure 16. Apple scab infection on fruit.

Recent wet seasons wreak havoc

Apple scab disease pressure is determined by the number of spores present (the inoculum level) and the suitability of weather conditions for these spores to germinate. Early-season spore pressure comes mostly from last season's leaves on the orchard floor. Effective disease control is achieved by reducing inoculum, appropriate spray choice, good coverage and the right timing. While the over-wintering inoculum level and in-season chemical control programs can be managed, the weather cannot.

The relationship between *Venturia inaequalis* and wet conditions in spring, summer, and autumn is well understood. Even the most thorough protective and curative scab fungicide spray programs can fail when rainfall is heavy and protracted during the growing season. The challenge is exacerbated when such conditions persist from spring into summer, and for multiple seasons, leading to a rapid build-up of disease and carry-over inoculum.

Apple scab incidence was particularly high in the key apple-growing regions of NSW and other states in 2022–23, following several seasons of above-average rainfall at critical times. At Orange, rainfall data recorded at the local airport provide insight into the conditions contributing to increased disease pressure and subsequent loss of effective control in recent seasons (Figure 17).

Dealing with high disease pressure following multiple seasons of infections requires a proactive approach to reduce the disease potential and protect the new season's leaves and fruit. Orchard hygiene and a targeted spring fungicide program will be critical for controlling the disease.

Hygiene first – spray, sweep 'n' mulch

Autumn–winter hygiene programs for apple scab aim to accelerate the breakdown of last season's leaf litter so that most, if not all, leaves are gone before green tip. This will significantly reduce the primary inoculum pressure in the spring as overwintering spore bodies form in the fallen leaves within 4 weeks of leaf-fall. Therefore, any action that helps break down leaves soon after leaf drop will result in fewer surviving spores in the spring; the sooner leaves are broken down after leaf-fall, the better.

A postharvest foliar spray using a high-analysis nitrogen fertiliser, such as low-biuret urea (46% N), can encourage the microbial breakdown of infected apple leaves. This approach is most effective

in areas with a mild autumn–winter climate where microbial activity is sufficient to facilitate leaf decay. Sweeping (Figure 18) and mulching also help break down leaf matter and reduce carry-over scab inoculum. The effective breakdown of last season's leaves breaks the disease cycle, particularly following season(s) of high infection. Importantly, this practice has the added benefit of reducing disease carry-over for another important apple disease, alternaria leaf blotch and fruit spot, which also overwinters in fallen leaves and twigs. For more information on alternaria leaf blotch and fruit spot, refer to page 98.

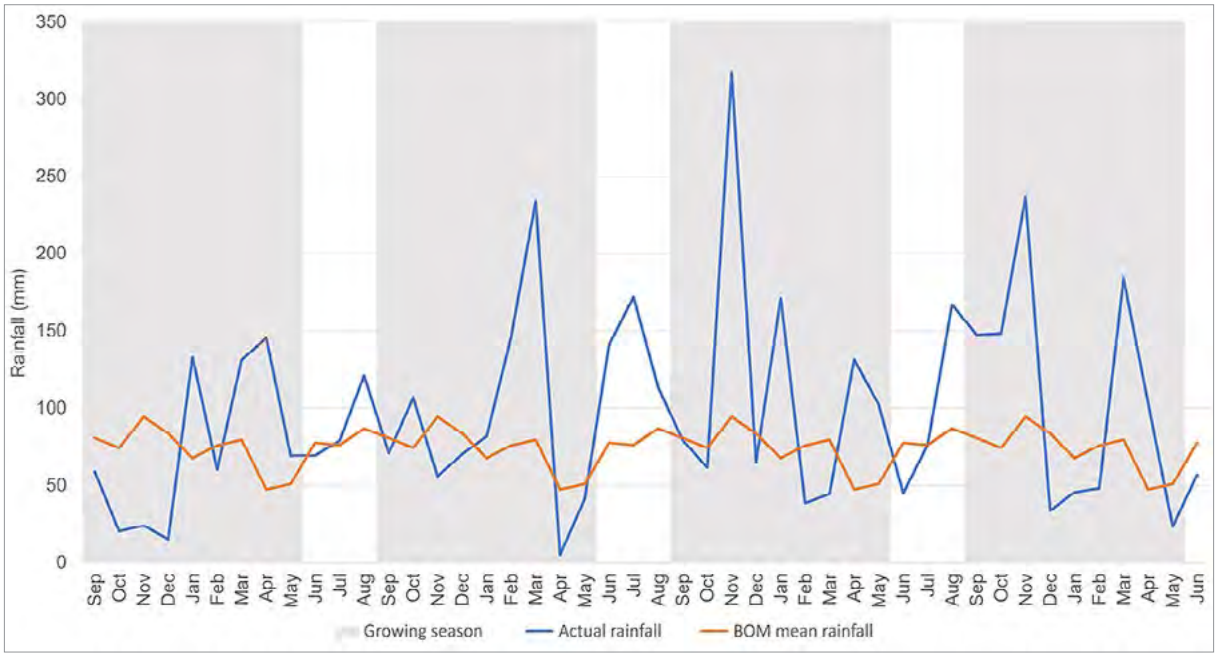


Figure 17. Rainfall (monthly actual and BOM monthly mean) recorded at Orange Airport over 4 seasons from 2019 to 2023. Grey shading shows the growing season.

Figure 18. Tractor-mounted orchard sweepers help move fallen leaves into the inter-row, where they can be mulched into smaller pieces to accelerate their breakdown.

Controlling the primary infection phase

The primary infection phase is when ascospores (fungal spores) from overwintering sources are available for release, and the host apple tree has exposed and vulnerable tissues. Typically, this is from early green tip to early December in the NSW apple production regions of Orange and Batlow. The peak of primary spore release usually corresponds with flowering in apples, making this a critical time for effectively controlling the disease.

For a list of fungicides registered to control apple scab in NSW orchards, refer to page 102. Some chemicals have protective activity only, while others have some curative activity if applied immediately after infection. Consult the product labels and your chemical supplier for advice on product selection and use.

By the end of spring, the overwintering inoculum sources are usually exhausted, and the risk of new primary infection declines significantly. If the orchard is free of primary infection at the end of spring, the potential for later-season infection (secondary) is dramatically reduced, and protective spray programs can be reduced without significant risk.

Note: any decision to reduce a protective spray program after the primary infection phase should be based on thorough scouting of leaves and fruit in early December in all orchard blocks.

If leaf or fruit infection is detected at any stage during the primary infection phase, then the risk of secondary infection will be high for the remainder of the season; a thorough protective spray program will need to be maintained until harvest. During the secondary infection phase, lesions from primary infections on leaves and fruit produce spores known as conidia. These are splashed throughout the tree canopy during rain, which can cause a rapid increase in new infections. This is why it is best to gain control in the primary infection phase.

Figure 19 shows the disease life cycle of apple scab, including the primary (ascospore) and secondary (conidium) phases.

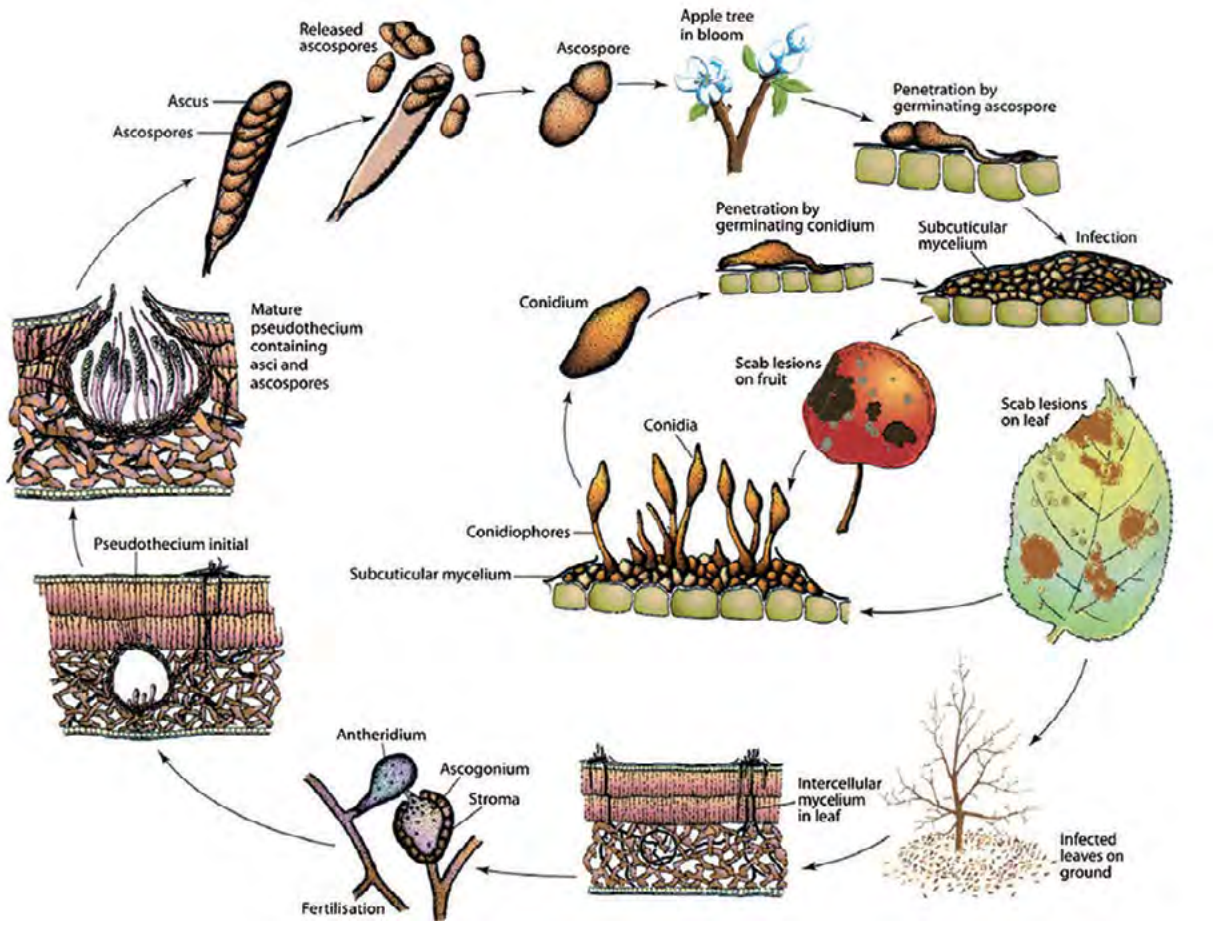


Figure 19. The disease life cycle of apple scab. Source: Bowen et al (2011); originally published in Agrios, *Plant Pathology*, San Diego.

Spray coverage and timing are critical

The primary infection phase is the greatest risk due to overwintering spore release and when the new season foliage, shoots and fruitlets are expanding rapidly. Regular spraying and thorough spray coverage are critical to account for chemical dilution by plant growth and wash-off by heavy rainfall.

Remember: there is no such thing as 100% spray coverage. The higher the inoculum level is in the orchard, the greater the likelihood of a spore landing on an unprotected area of a leaf or on fruit, resulting in an infection.

To ensure spray coverage is as good as it can be:

- Service your sprayer at least annually and check the condition of the pump, nozzles, filters and pressure gauge. Talk with your spray equipment supplier about the best nozzles for your spraying application.
- Calibrate the spray rig at least annually and before the start of the spraying season to ensure the output volume is appropriate and that all nozzles are functioning according to their specification.
- Check spray deposition and droplet size at various heights and depths in the canopy using water-sensitive paper. If the sprayer is not reaching all parts of the canopy effectively, with good coverage and droplet size, the disease will not be controlled.

Effective control of the primary infection phase is only achieved when good coverage is paired with appropriate product choice and application timing. For a full list of active ingredients currently registered to control apple scab in NSW orchards, refer to page 102. Also, read the label and consult an agronomist for advice on product selection and application. Prevention is always better than cure, so it is wise to adopt a tight-cover spray program based on protective fungicides rather than relying on the limited number of available curative products.

Monitor weather conditions and infection periods to guide spray timing decisions. Many modern weather stations come with in-built or online apple scab prediction models that predict infection risk using data from your orchard. Growers are encouraged to purchase and install a weather station with apple scab prediction capability. Such systems can also include degree day models for key pest species such as codling moth and light brown apple moth.

Avoiding fungicide resistance

Venturia inaequalis is recognised internationally as a high-risk pathogen for developing fungicide resistance. Therefore, careful selection and use of the available products are essential to prevent or delay fungicide resistance.

Fungicides are grouped according to their chemical activity (refer to page 144), and the chemical group is also clearly shown on the product label. Fungicide labels include a fungicide resistance warning and instructions for any limits on the number of applications that can be applied. They also have advice on rotation with products from other groups. Always follow the label advice and be aware of the resistance warning. For more information on fungicide resistance management strategies, visit the CropLife Australia website (https://www.croplife.org.au/).

Dr Andrew Taylor of the Western Australian Department of Primary Industries and Regional Development (WA DPIRD) is currently leading a national black spot resistance screening study and is inviting the submission of scab infection samples from the key apple-growing states of Australia. NSW DPI has agreed to help facilitate sample submissions and will be contacting NSW commercial apple growers with more information about the project and how to participate.

Reference

Bowen JK, Mesarich CH, Bus VG, Beresford RM, Plummer KM, Templeton MD (2011) *Venturia inaequalis*: the causal agent of apple scab, *Molecular plant pathology*, 12(2): 105–22.

Pests

Table 2. 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/ nectarines	Plums/ Prunes	Persimmons	
Ants	*Pheidole megacephala* and *Ochetellus glaber*	✗	✗	✗	✗	✗	✗	✓	page 29
Apple dimpling bug	*Campylomma liebknechti*	✓	✗	✗	✗	✗	✗	✗	page 31
Apple leafhopper	*Edwardsiana froggatti*	✓	✓	✗	✗	✗	✗	✗	page 33
Australian plague locust	*Chortoicetes terminifera*	✓	✓	✓	✓	✓	✓	✓	page 34
Black peach aphid and green peach aphid	*Brachycaudus persicae* and *Myzus persicae*	✗	✗	✓	✓	✓	✓	✗	page 35
Bryobia mite	*Bryobia rubrioculus*	✓	✓	✓	✓	✓	✓	✗	page 37
Budworms (*Heliothis*)	*Helicoverpa* species	✓	✓	✓	✓	✓	✓	✗	page 39
Carpophilus beetle (dried fruit beetle)	*Carpophilus* species	✗	✗	✓	✓	✓	✓	✗	page 41
Cherry aphid	*Myzus cerasi*	✗	✗	✓	✓	✓	✓	✗	page 43
Clearwing moth	*Ichneumenoptera chrysophanes*	✗	✗	✗	✗	✗	✗	✓	page 45
Codling moth	*Cydia pomonella*	✓	✓	✗	✗	✗	✗	✗	page 47
European earwig	*Forficula auricularia*	✗	✗	✓	✓	✓	✓	✗	page 51
European red mite	*Panonychus ulmi*	✓	✓	✓	✓	✓	✓	✗	page 53
Fruit tree borer	*Maroga melanostigma*	✗	✗	✓	✓	✓	✓	✗	page 56
Harlequin bug	*Dindymus versicolor*	✓	✗	✗	✗	✗	✗	✗	page 57
Light brown apple moth	*Epiphyas postvittana*	✓	✓	✓	✓	✓	✓	✓	page 59
Loopers including green loopers	Various species	✓	✓	✓	✓	✓	✓	✓	page 63

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

Common name	Scientific name	Which crops are primarily affected?							Where to look
		Apples 	Pears 	Apricots 	Cherries 	Peaches/ nectarines 	Plums/ Prunes 	Persimmons 	
Mealybugs including long-tailed mealybug	Various species	✓	✓	✗	✗	✗	✗	✓	page 65
Oriental fruit moth	*Grapholita molesta*	✓	✓	✓	✓	✓	✓	✗	page 67
Oystershell scale	*Diaspidiotus ostreaeformis*	✓	✓	✓	✓	✓	✓	✗	page 69
Pear and cherry slug	*Caliroa cerasi*	✗	✓	✗	✓	✗	✗	✗	page 70
Pear leaf blister mite	*Eriophyes pyri*	✗	✓	✗	✗	✗	✗	✗	page 71
Plague thrips	*Thrips imaginis*	✓	✓	✓	✓	✓	✓	✗	page 72
Queensland fruit fly	*Bactrocera tryoni*	✓	✓	✓	✓	✓	✓	✓	page 74
Rutherglen bug	*Nysius vinitor*	✓	✓	✓	✓	✓	✓	✗	page 82
San José scale	*Diaspidiotus perniciosus*	✓	✓	✓	✓	✓	✓	✗	page 83
Two-spotted mite	*Tetranycus urticae*	✓	✓	✓	✓	✓	✓	✗	page 85
Weevils	Various species	✓	✓	✓	✓	✓	✓	✗	page 87
Western flower thrips	*Frankliniella occidentalis*	✓	✓	✓	✓	✓	✓	✓	page 89
Wingless grasshoppers	*Phaulacridium vittatum*	✓	✓	✓	✓	✓	✓	✗	page 91
Woolly apple aphid	*Eriosoma lanigerum*	✓	✓	✗	✗	✗	✗	✗	page 92

Diseases

Table 3. Key diseases 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/ Nectarines 	Plums/ Prunes 	Persimmons 	
Alternaria leaf blotch and fruit spot	*Alternaria* species	✓	✗	✗	✗	✗	✗	✗	page 98
Angular leaf spot	*Cercospora* species and *Pseudocercospora* species	✗	✗	✗	✗	✗	✗	✓	page 100
Apple scab and pear scab	*Venturia inaequalis* and *Venturia pirina*	✓	✓	✗	✗	✗	✗	✗	page 102
Bacterial canker	*Pseudomonas syringae* pv. *syringae*	✗	✗	✓	✓	✓	✓	✗	page 104
Bacterial spot	*Xanthomonas arboricola* pv. *pruni*	✗	✗	✓	✗	✓	✓	✗	page 106
Bitter rot	*Glomerella cingulata* (anamorph: *Colletotrichum gloeosporioides*)	✓	✓	✗	✗	✗	✗	✗	page 107
Blossom blight and brown rot	*Monilinia* species	✗	✗	✓	✓	✓	✓	✗	page 108
Circular leaf spot	*Mycosphaerella* species	✗	✗	✗	✗	✗	✗	✓	page 111
Crown gall	*Agrobacterium tumefaciens*	✗	✗	✓	✓	✓	✓	✗	page 112
Fly speck	*Schizothyrium pomi*	✓	✓	✗	✗	✗	✗	✗	page 113
Freckle	*Venturia carpophilum*	✗	✗	✓	✓	✓	✓	✗	page 114
Peach leaf curl	*Taphrina deformans*	✗	✗	✗	✗	✓	✗	✗	page 115
Phytophthora root and collar rot	*Phytophthora* species	✓	✓	✓	✓	✓	✓	✗	page 117
Powdery mildew	*Podosphaera leucotricha*	✓	✓	✗	✗	✗	✗	✗	page 119
Rust	*Tranzschelia discolor*	✗	✗	✓	✓	✓	✓	✗	page 121
Shot hole	*Stigmina carpophila*	✗	✗	✓	✓	✓	✓	✗	page 123
Silver leaf	*Chondrostereum purpureum*	✓	✗	✓	✓	✓	✓	✗	page 125
Sooty blotch	*Gloeodes pomigena*	✓	✓	✗	✗	✗	✗	✗	page 126

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Apple blossom development stages

Photos by Shane Hetherington, NSW DPI.

Figure 20. Dormant.

Figure 21. Green tip.

Figure 22. Spurburst.

Figure 23. Pink.

Figure 24. King bloom.

Figure 25. Full bloom.

Stone fruit blossom development stages

Photos by Shane Hetherington, NSW DPI.

Figure 26. Dormant.

Figure 27. Budswell.

Figure 28. Budbreak.

Figure 29. Full bloom.

Figure 30. Petal fall.

Figure 31. Shuckfall.

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

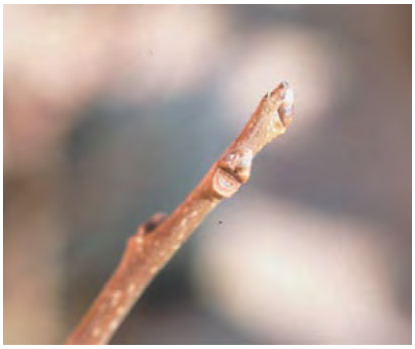

Figure 32. Late dormancy.

Figure 33. Green leaf tips.

Figure 34. First leaves unfolded.

Figure 35. Flower bud develops on new growth.

Figure 36. Flower sepals begin to separate.

Figure 37. Full flowering (50% open).

Figure 38. Flowers fading.

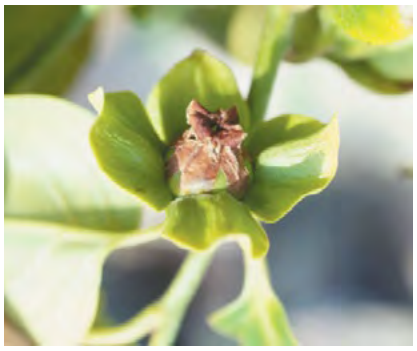

Figure 39. Fruit set, petals browning.

Figure 40. Early fruit development.

Figure 41. Late fruit development.

Figure 42. Start of fruit colouration.

Figure 43. Fruit ripe.

Pests

Ants

Various species

Ants are not a direct pest of persimmons, however, they facilitate mealybug (page 65) and scale insect (page 69 and page 83) damage. This is due to the important role ants play in farming and protecting these species. Their risk period is therefore closely associated with those pests.

Risk period

Table 4. The peak risk period for ants in persimmon orchards.

Budswell/ green tip	Shoot extension	Flowering and fruit development	Harvest	Postharvest	Dormancy

Pest identification

Many ant species are recorded in Australia, both native and introduced. Those most commonly associated with persimmons are the coastal brown ant (*Pheidole megacephala*; Figure 44) and the black house ant (*Ochetellus glaber*; Figure 45). Coastal brown ant workers are 1.5–2.5 mm long and the soldiers are 3.5–4.5 mm. They are shiny light-yellow brown to dark brown. Black house ants are 2–3 mm long and black to brown.

Damage

Ants do not damage persimmons directly, but they are usually associated with the presence of mealybugs or scale insects that excrete honeydew, which ants feed on. When searching the persimmon canopy for honeydew, ants will interfere with the predators and parasites of mealybugs and scale insects, defending the honeydew-producing pests from their natural predators.

Sooty mould is a black fungus that grows on honeydew and is another indirect effect of ants protecting mealybug and scale. Sooty mould results in a superficial black coating on fruit and leaves that can affect fruit colour development and the fruit cleaning process in the packing shed, increasing processing costs.

Monitoring

Monitoring for ants can be done while checking the canopy for other pests including mealybug and scale. Monitor throughout the growing season from flowering to early postharvest. As ant activity is usually driven by warmth, monitoring during the warmer part of the day is recommended. Action should be considered when ants are found on 50% or more of the inspected shoots.

Figure 44. Coastal brown ants (*Pheidole megacephala*). Photo: Australian Environmental Pest Managers Association 2021.

Figure 45. Black house ant (*Ochetellus glaber*). Photo: Australian Environmental Pest Managers Association 2021.

Management

Cultural and physical

Cultural controls for ants can include:

- destroying ant nests within or near the orchard
- skirting (removing low-hanging branches and weeds growing into the canopy) to reduce pathways for ants into the trees
- applying a sticky product on the lower tree trunk to make a physical barrier to ants.

Biological

There are currently no effective biological control agents effective against ants.

Chemical

The chemical options for controlling ants are listed in Table 5.

Table 5. Registered products for ants in NSW persimmon orchards.

Active constituent (example trade name)	Insecticide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Pyrethrins/piperonyl butoxide (Py-Bo)	3A	1	High	All fruit crops[3]
Pyriproxyfen (Distance® Plus)	7C	Not required when used as directed	Low	Orchards; bait application

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

Apple dimpling bug

Campylomma liebknechti

Commonly known as the apple dimpling bug (ADB) on mainland Australia, *Campylomma liebknechti* is primarily a pest of apples.

Risk period

Table 6. The peak risk period for apple dimpling bug.

Budswell/ 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 46).

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 47).

Figure 46. Adult apple dimpling bug.

Figure 47. Dimpling on an apple caused by apple dimpling bug feeding during bloom.

Monitoring

The main risk period for ADB occurs between early pink and petal fall. The danger is especially acute if fruit tree flowering coincides with, or immediately follows, the flowering of native trees in the surrounding bush. In particular be aware of tree lucerne (Figure 48), wattle (Figure 49) 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 spurburst 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 bug numbers can quickly escalate to significant levels with changes in weather. Experience has shown that ADB numbers often increase following the arrival of warm, northerly winds.

Figure 48. Tree lucerne is an apple dimpling bug host.

Figure 49. Wattle 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 preferentially remove any apples that have signs of dimpling damage. Some damaged fruit will drop naturally between petal fall and harvest.

Biological

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

Chemical

The chemical options for controlling apple dimpling bug are listed in Table 7.

Table 7. Registered or permitted products for apple dimpling bug in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + novaluron (Cormoran®)	4A + 15	70	Medium	Apples
Bifenthrin (Talstar® 80 SC)	3A	0	High	Apples
Chlorpyrifos (Strike-Out® 500 WP)	1B	14	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 (Calypso®)	4A	21	Medium	Apples

[1] WHP = withholding period. [2] Always refer to the label.

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.

Risk period

Table 8. The peak risk period for apple leafhopper.

Budswell/ 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 50). 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 51). If the infestation is severe, apple leafhopper can cause premature leaf drop.

Figure 50. Apple leafhopper.

Figure 51. 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

Table 9. Registered product for apple leafhopper in NSW.

Active constituent (example trade name)	Insecticide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Maldison (Hy-Mal®)	1B	3	High	Pome fruit

[1] WHP = withholding period. [2] 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 10. The peak risk period for Australian plague locust.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Australian plague locusts can be green or brown (Figure 52), 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 52. Australian plague locust adult.

Damage

Australian plague locust swarms can cause severe damage to 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 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.

Management

Cultural and physical

Australian plague locust eggs can be reduced by cultivating egg beds, however, 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 options for controlling the Australian plague locust are listed in Table 11. There are no registered or permitted products to control this pest in persimmons.

Table 11. Registered or permitted products for Australian plague locust in NSW.

Active constituent (example trade name)	Insecticide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Fenitrothion (Sumithion® ULV)	1B	14	High	Apples, cherries
Maldison (Hy-Mal®)	1B	3	High	Pome fruit, stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

Black peach aphid and green peach aphid

Brachycaudus persicae and *Myzus persicae*

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

Risk period

Table 12. The peak risk period for black peach aphids and green peach aphids.

Budswell/ 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 53).

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 54).

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 budswell to ripening. Aphid numbers can increase quickly, therefore regular inspections are important.

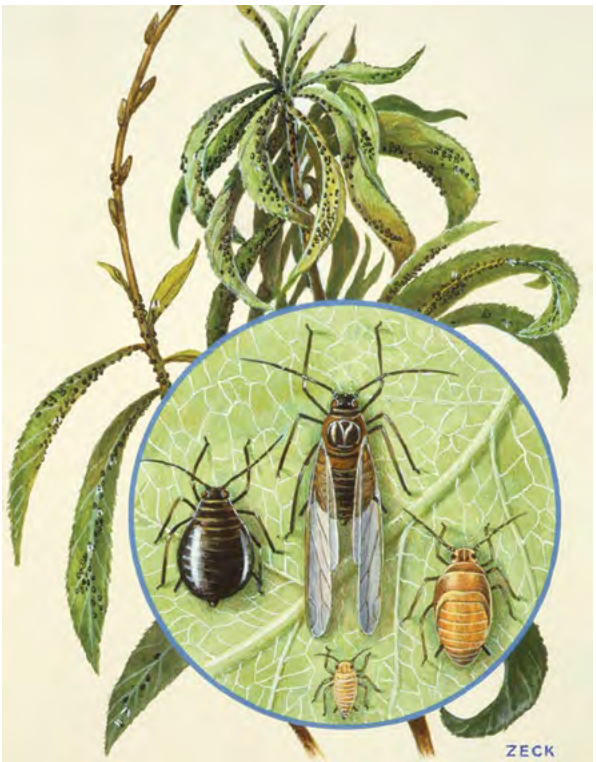

Figure 53. Various life stages of the black peach aphid. Source: Adapted from Zeck 1965.

Figure 54. 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 55) 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 impact on 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 budburst, eggs and newly hatched nymphs are susceptible to oil sprays applied to control San José scale (page 83).

Figure 55. Lacewing larvae are important natural predators of aphids.

Chemical

Chemical options for controlling BPA and GPA are in Table 13.

Table 13. Registered products for black peach aphids (BPA) and green peach aphids (GPA) in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + novaluron (Cormoran®)	4A + 15	7	Medium	Stone fruit for BPA and GPA
Clothianidin (Samurai®)	4A	7	High	Peaches and nectarines GPA only
Imidacloprid (Confidor® 200 SC)	4A	21	Medium	Stone fruit
Maldison (Hy-Mal®)	1B	3	High	Stone fruit for BPA and GPA
Methomyl (Methomyl 225)	1A	1	High	Stone fruit for GPA only
Pirimicarb (Pirimor®)	1A	2	Medium	Stone fruit for BPA and GPA
Pymetrozine (Chess®)	9B	28	Low	Stone fruit for BPA and GPA
Spirotetramat (Movento®)	23	21	Medium	Stone fruit for BPA only
Sulfoxaflor (Transform® Isoclast™)	4C	7	Medium	Stone fruit for BPA and GPA

[1] WHP = withholding period. [2] Always refer to the label.

Note: in addition to the above chemicals, the active constituent thiacloprid (Calypso®), although not registered for control of 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 tissues with their sucking mouthparts. Bryobia mites have become more prevalent in recent years as pest and disease control programs have moved away from broad-spectrum chemicals.

Risk period

Table 14. The peak risk period for bryobia mite.

Budswell/ 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 the body (Figure 56). They are often seen pressed flat against the leaf surface or as masses of red eggs on branches and stems (Figure 57). Without a microscope or good hand lens, bryobia mite might 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 appears as whitish-grey spots, giving the leaf a stippled appearance. Heavily infested leaves will become pale and can prematurely fall. 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. Leaf samples can be collected and inspected using a microscope to determine the number of eggs, active mites and predatory mites and other beneficial insects present. Commercial mite monitoring services exist in some growing regions.

Figure 56. An adult bryobia mite.

Figure 57. Bryobia mite eggs are laid in large groups on branches and stems. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

Management

Cultural and physical

Dusty environments 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 mite can be controlled by predatory mites including *Galendromus pyri*. Other naturally occurring biological control agents of pest mites include lacewings and *Stethorus* 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 15) for pest mites usually includes a winter (dormant) or early spring (budswell, green-tip) oil spray to control overwintering eggs, followed by targeted miticide application(s) during the growing season as determined by monitoring.

Table 15. Registered or permitted products for bryobia mite in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Bifenazate (Acramite®)	20D	Apricots, plums, nectarines, peaches 3 Pome fruit 7	Low	Pome fruit, apricots, nectarines, peaches, plums
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 (Vendex® 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 (S) as polysulfide sulfur (Grochem® Lime Sulphur)	M2	Not required when used as directed	Medium	Pears, apricots, nectarines, peaches, plums, prunes; stone fruit dormant to budswell spray only

[1] WHP = withholding period. [2] 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 major insect pests of many agricultural and horticultural crops in Australia. The moth larvae can cause extensive feeding damage and also create entry points for secondary pests and diseases.

Risk period

Table 16. The peak risk period for budworms.

Budswell/ 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 58). These will then develop into the identifying characteristic between species. Female moths (Figure 59) generally have brown forewings, while males are usually cream.

Damage

Helicoverpa spp. larvae will bore into developing fruitlets (Figure 60), 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, so trees should also be monitored then.

Figure 58. *Helicoverpa* spp. caterpillars.

Management

Cultural and physical

Helicoverpa spp. will lay eggs on a wide range of plants, including weeds, therefore, managing these, particularly during dormancy, can help to reduce any resident population.

Biological

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

Figure 59. Female *Helicoverpa* spp.

Figure 60. *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 17).

Table 17. Registered or permitted products for budworms in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Abamectin + chlorantraniliprole (Voliam Targo®)	6 + 28	7	High	Pome fruit
Bacillus thuringiensis subsp. *Aizawai* (Bacchus® WG)	11C	Not required when used as directed	Low	All crops[3]
Bacillus thuringiensis subsp. *Kurstaki* (DiPel®)	11	Not required when used as directed	Low	All crops
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	Apples, pears
Indoxacarb (Avatar® eVo)	22A	Stone fruit (except cherries) 7 Pome fruit and cherries 14	Low	Pome fruit, stone fruit
Methomyl (Lannate-L®)	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

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

Carpophilus beetle (dried fruit beetle)

Carpophilus species

Carpophilus beetles can cause significant 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 18. The peak risk period for carpophilus beetle.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Carpophilus beetles are small (2–3 mm long; Figure 61) and black or brown (Figure 62). 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 forked tail.

Damage

Most commercial damage is done to ripening stone fruit, which can be damaged on the tree as beetles burrow into the fruit, particularly near the stem end suture line. In other fruits 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 rains and rotting fruit are ideal conditions for breeding. Carpophilus adults are a major vector of brown rot (page 108).

Figure 61. Chewing damage on a nectarine and Carpophilus beetle (inset image).

Monitoring

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

Figure 62. Carpophilus beetle. Photo: Pest and Diseases Image Library, Bugwood.org.

Management

Cultural and physical

The most important management strategy for Carpophilus 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.

A combination of weekly monitoring and/or mass trapping between stone hardening and harvest, orchard hygiene and good 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 after harvest will help reduce the resident pest population. Placing traps (Figure 63) 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 19.

Figure 63. Carpophilus pheromone trap. Photo: Dan Papacek, Bugs for Bugs.

Table 19. Registered or permitted products for Carpophilus beetle in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Bifenthrin (Bifenthrin® 250 EC)	3A	1	High	Stone fruit except cherries
Bifenthrin (PER82062, expires 31.12.23)	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

[1] WHP = withholding period. [2] Always refer to the label.

Cherry aphid

Myzus cerasi

Cherry aphids can be a significant pest in all stone fruits, feeding on leaves and shoots, resulting in reduced and deformed growth.

Risk period

Table 20. The peak risk period for cherry aphid.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Adult cherry aphids are dark (Figure 64) and approximately 2 mm long. The adult population consists of winged and wingless individuals. The nymphs are dark brown to black. Cherry aphid eggs are shiny, oval-shaped (Figure 65) and usually found on the underside of leaves.

Figure 64. Cherry aphids. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

Figure 65. 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 budbreak for aphids (Figure 66). Particular attention should be paid to the terminal shoot tips. Continued monitoring each fortnight until harvest is recommended.

Figure 66. 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 harbours and therefore reduce migrating aphid populations.

Biological

Fortunately it is possible to achieve good aphid control 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 67).

Figure 67. Lady beetle adult, eggs and larvae.

Chemical

The chemical options for controlling cherry aphid are listed in Table 21.

Table 21. Registered or permitted products for cherry aphid in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Maldison (Hy-Mal®)	1B	3	High	Stone fruit
Pirimicarb (Pirimor®)	1A	2	Medium	Stone fruit
Spirotetramat (Movento®)	23	21	Medium	Stone fruit
Sulfoxaflor (Transform® Isoclast™)	4C	7	Medium	Stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

Clearwing borer

Ichneumenoptera chrysophanes

Early spring is a critical time for monitoring and applying controls, although clearwing borers can be present all season, particularly in warmer regions of Northern NSW.

Risk period

Table 22. The peak risk period for clearwing borer in persimmon orchards.

Budswell/ green tip	Shoot extension	Flowering and fruit development	Harvest	Postharvest	Dormancy

Pest identification

The predominant species of clearwing borer found in NSW and Qld persimmon orchards is *Ichneumenoptera chrysophanes* (formerly *Carmenta chrysophanes*). The adult borers look similar to wasps, with clear wings and narrow bodies. Males are typically black with bands of yellow hairs (Figure 68), while the females are black with bands of orange (Figure 68). 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 69).

Figure 68. Male (left) and female (right) clearwing borers. Photo: *Integrated Pest and Disease Management Manual for Persimmons* 2017 (Queensland Government, Hort Innovation Persimmon Fund).

Damage

The larval stage of the clearwing borer damages persimmon trees. They tunnel under the bark, but unlike other fruit tree borers, do not bore into the heart wood. Their feeding sites (usually covered in sawdust-like frass) can result in significant damage to the tree's conductive tissues (Figure 70). 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. Typically, these traps will detect significant activity in early spring, indicating the need for control measures

Figure 69. Clearwing borer larvae. Photo: *Integrated Pest and Disease Management Manual for Persimmons* 2017 (Queensland Government, Hort Innovation Persimmon Fund).

to be implemented early. 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.

Figure 70. Clearwing borer feeding damage and associated frass covering. Photo: *Integrated Pest and Disease Management Manual for Persimmons* 2017 (Queensland Government, Hort Innovation Persimmon Fund).

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 71) 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-lay. 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.

Figure 71. Clearwing borer pheromone mating disruption dispenser.

Table 23 lists the pheromone mating disruption product currently permitted for managing clearwing borer in NSW persimmon orchards. There are currently no registrations or permits for chemical sprays for this pest in persimmons.

Table 23. Chemical registered or permitted for managing clearwing borer in persimmons in NSW.

Active constituent (example trade name)	Insecticide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Insense mating disruption agent (PER88722, expires 31.5.28)	Pheromone	0	Nil	Persimmons

[1] WHP = withholding period. [2] Always refer to the label.

Codling moth

Cydia pomonella

Codling moth is one of the most damaging pests of apple and pears in Australia. Other hosts susceptible to codling moth include crab apple, some stone fruits, walnuts and quinces.

Risk period

Table 24. The peak risk period for codling moth.

Budswell/ 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, wings are held in a tent-like structure over their bodies (Figure 72). Larvae are white to light pink with a dark brown head. They appear worm-like and 15–19 mm long. Larvae are most commonly seen when damaged fruit is cut open for inspection (Figure 73).

Figure 72. Codling moth larvae (left) and adult (right).

Figure 73. 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. 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 74). Most of the damage occurs as the moth tunnels into the fruit and feeds on the flesh and seeds (Figure 75). 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 74. Sting marks on the apple surface. Photo: Eugene E Nelson, Bugwood.org.

Figure 75. Sawdust-like frass covering codling moth larvae entry on an apple.

Management

Cultural and physical

Where possible, infested fruit (either in 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 air.

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 76) 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 77) 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. It is likely that *M. ridens* will work best as part of an integrated control program using mating disruption and avoiding broad-spectrum chemicals.

Figure 76. A delta trap with sticky inserts and a pheromone lure being used to monitor adult codling moth activity.

Figure 77. 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 25) might be necessary to reduce a large resident population.

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- Soft on key beneficial insects, including beneficial mites*
- Short withholding period

For full information on pest spectrum and IPM profile, visit vayego.com.au or speak to your advisor.

*When used as directed.

Table 25. Registered or permitted products for codling moth in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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
Cyclaniliprole (Teppan®)	28	28	Medium	Apples
Cydia pomonella granulosis virus (CYD-X®)	Biological insecticide	Not required when used as directed	Low	Apples, pears
Fenoxycarb (Insegar®)	7B	14	Low	Apples, pears
Indoxacarb (Avatar® eVo)	22A	14	Low	Apples, pears
Maldison (Hy-Mal®)	1B	3	High	Pome fruit
Mating disruption agent (Isomate®)	Pheromone	Not required when 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 (Calypso®)	4A	21	Medium	Pome fruit

[1] WHP = withholding period. [2] 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 26. The peak risk period for European earwigs.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Adult European earwigs 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 78).

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 79) that can be the perfect host for brown rot (page 108). In cherries, significant damage can occur when earwigs feed on the stems of developing fruitlets (Figure 80).

Figure 78. Adult European earwigs, male (left) and female (right).

Figure 79. European earwig feeding damage on ripening cherries.

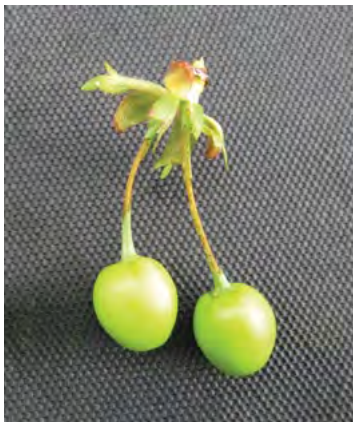

Figure 80. European earwig feeding damage on young cherry stems.

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 earwig 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 significantly reduce populations. In apple and pear orchards, European earwig is considered a beneficial insect because it predates on woolly apple aphids.

Chemical

The chemical options for controlling European earwig are listed in Table 27.

Table 27. Registered or permitted products for European earwig in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Carbaryl (Bugmaster®)	1A	35	High	Stone fruit except cherries
Chlorpyrifos (Strike-Out® 500 EC)	1B	14	High	Stone fruit except cherries; spray or bait
Fipronil (Albatross® 800)	2B	Do not graze treated area	High	Cherries; single ground spray only
Indoxacarb (Avatar® eVo)	22A	Stone fruit 7 Cherries 14	Low	Stone fruit
Indoxacarb (PER11002, expires 31.3.25)	22A	14	Low	Cherries
Pyrethrins + piperonyl butoxide (Py-Bo®)	3A	1	High	Fruit crops

[1] WHP = withholding period. [2] 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 also occurs in stone fruit trees, but this is less common.

Risk period

Table 28. The peak risk period for European red mite.

Budswell/ 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 81). 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 top. When infestations are heavy, eggs will be found clustered in hundreds around branch angles and buds (Figure 82).

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 present in the canopy, although this is more common with two-spotted mite (TSM; page 85). 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 81. A female European red mite.

Figure 82. European red mite eggs clustered around a branch angle.

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 Protecting 'beneficials' on page 96.

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 83) 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, are 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.

Figure 83. Adult predatory mites on an apple leaf.

Chemical

Decisions to spray for ERM are best made based on the results of regular mite monitoring. The chemical options for controlling European red mite are listed in Table 29.

Table 29. Registered or permitted products for European red mite in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Abamectin (Vertimec®)	6A	14	High	Apples, pears
Abamectin + chlorantraniliprole (Voliam Targo®)	6 + 28	7	High	Pome fruit
Bifenazate (Acramite®)	20D	Apricots, nectarines, peaches, plums 3 Pome fruit 7	Low	Apples, pears, apricots, nectarines, peaches, plums
Cyflumetofen (Danisaraba®)	25A	7	Low	Pome fruit
Etoxazole (Paramite®)	10B	7	High	Pome fruit, stone fruit except cherries

Table 30. Registered or permitted products for European red mite in NSW, page 2.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Fenbutatin oxide (Vendex® Miticide)	12B	Apples, pears 2 Peaches, nectarines 14	Low	Apples, pears, peaches, nectarines
Hexythiazox (Calibre®)	10A	3	Low	Apples, pears, stone fruit
Horticultural mineral oil (various)	Paraffinic oil and petroleum oil	1	Low	Pome fruit, stone fruit
Maldison (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

[1] WHP = withholding period. [2] Always refer to the label.

Fruit tree borer

Maroga melanostigma

Fruit tree borer is the larval stage of *Maroga melanostigma,* an Australian native moth that will affect a wide range of tree species; *Prunus* (stone fruits) are particularly susceptible.

Risk period

Table 30. The peak risk period for fruit tree borer.

Budswell/ 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. The larvae are cream with a dark head (Figure 84).

Damage

Fruit tree borers damage stone fruit trees when the larvae (caterpillar) 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.

Figure 84. Fruit tree borer larva.

Monitoring

Inspect structural limbs and tree trunks for tell-tale sawdust patches (Figure 85).

Figure 85. Sawdust patch on a borer-infested tree.

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, however it is uncertain if this will provide commercial level control.

Chemical

For effective larvae control, use the registered chemical carbaryl (Table 31), expose and saturate feeding sites with the spray, ensuring that some insecticide penetrates the borer tunnels.

Table 31. Registered product for fruit tree borer in NSW.

Active constituent (example trade name)	Insecticide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Carbaryl (Bugmaster®)	1A	35	High	Stone fruit except cherries

WHP = withholding period. [2] 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 fruits 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 32. The peak risk period for the harlequin bug.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

The adult harlequin bug is about 12 mm long and is very conspicuous (Figure 86). The head, and 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 87). 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 88).

Figure 86. Adult harlequin bug.

Figure 87. Mid-season harlequin bug feeding damage to Cripps Pink (Pink Lady) apples.

Figure 88. Harlequin bug juveniles are often found swarming on tree trunks and timber posts in or near the orchard.

Figure 89. Marshmallow (*Malva parviflora*).

Figure 90. Dock (*Rumex crispus*).

Figure 91. Wireweed (*Polygonum erectum*).

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 89), *Rumex* (dock; Figure 90) and *Polygonum* (wireweed; Figure 91) 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 presently no chemicals registered for the control of harlequin bug in orchards in Australia, management of the pest is dependent on the adoption of cultural practices.

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 33. The peak risk period for light brown apple moth.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Adult moths are pale brown (Figure 92) 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 therefore more likely in cooler areas with mild summers. Feeding and pupating sites in fruit are usually accompanied by webbing.

Figure 92. Adult light brown apple moth.

Damage

Larvae (or caterpillars) feed between fruit or under leaves webbed to the fruit, chewing the fruit surface (Figure 93). This damage results in fruit being downgraded during sorting and packing.

Figure 93. Light brown apple moth caterpillar with typical surface feeding damage on apple.

Monitoring

Monitor for LBAM using pheromone traps (Figure 94), starting before flowering. Use trap catches to determine a biofix date (first sustained flight; see Calculating degree days for temperate fruit moth pests on page 94).

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 fruits 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 bacteria that is toxic to LBAM larvae when consumed, therefore it is an effective biological control method.

Pheromone ties (Figure 95) 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 lay.

Figure 94. Monitor pheromone traps weekly from early budburst. Photo: Evergreen Growers Supply.

Figure 95. Pheromone mating disruption is a non-chemical management option. Photo: Peaceful Valley Farm Supply.

Chemical

Table 34. Registered or permitted products for light brown apple moth in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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 31.1.24)	4A + 7C	28	Unknown	Persimmons
Bacillus thuringiensis (various)	11 and 11C	0	Low	All crops[3]
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; start at petal fall or 110 degree days from biofix[4]
Chlorpyrifos (Strike-Out® 500 WP)	1B	14	High	Apples, pears
Fenoxycarb (Insegar®)	7B	14	Low	Apples, pears

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Table 34. Registered or permitted products for light brown apple moth in NSW, page 2.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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 225)	1A	1	High	Apples
Methoxyfenozide (Prodigy®)	18	14	Low	Pome fruit
Methoxyfenozide (Venturi® Max)	18	7	Low	Persimmons
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

[1] WHP = withholding period.
[2] Always refer to the label.
[3] All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.
[4] Biofix = see Calculating degree days for temperate fruit moth pests on page 94.

Loopers

Various species

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

Risk period

Table 35. The peak risk period for loopers.

Budswell/ 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 96). Most looper larvae will grow to about 40 mm long and move with the characteristic looping of the body.

Figure 96. 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*, page 39).

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 perfect for monitoring loopers.

Management

Cultural and physical

Control of broadleaf weeds in the orchard might help reduce the potential for looper infestation.

Biological

Bacillus thuringiensis (Bt) is a bacterium that works as an effective biological control against loopers, affecting the caterpillar stage.

Chemical

The chemical options for controlling loopers are listed in Table 36.

Table 36. Registered or permitted products for loopers in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Bacillus thuringiensis subsp. *Aizawai* (Bacchus® WG)	11C	Not required when used as directed	Low	All crops[3]
Bacillus thuringiensis subsp. *Kurstaki* (DiPel®)	11	Not required when used as directed	Low	All crops
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	Pears
Trichlorfon (PER14743, expires 30.6.25)	1B	7	High	Persimmons

[1] WHP = withholding period. [2] Always refer to the label. [3] 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 fruits and persimmons and are a pest of concern for export markets.

Risk period

Table 37. The peak risk period for mealybugs.

Budswell/ 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 97). 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 98).

Figure 97. Adult female and juvenile mealybugs. Photo: Peggy Greb, USDA Agricultural Research Service, Bugwood.org.

Figure 98. Adult long-tailed mealybug. Photo: David Cappaert, Bugwood.org.

Damage

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

Monitoring

Fortnightly monitoring is important 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, see page 29.

Management

Cultural and physical

Good orchard hygiene is critical for mealybug control. Infested material should not be used as mulch, but should be removed from the orchard and destroyed. Mealybug infestations are worse

on dusty trees, thus you should 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 99 and Figure 100) and specific wasp parasites (Figure 101). Wasps can be extremely effective as they are highly mobile and efficient at seeking out their prey.

Figure 99. Brown lacewing.

Figure 100. Green lacewing.

Figure 101. Parasitic wasp.

Chemical

The chemical options for controlling mealybugs are listed in Table 38.

Table 38. Registered or permitted products for mealybugs in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + pyriproxyfen (Trivor®, PER89943, expires 31.1.24)	4A + 7C	28	Unknown	Persimmons
Acetamiprid + novaluron (Cormoran®)	4A + 15	Apples 70 Pears 35	Medium	Apples, pears
Buprofezin (Strident®)	16	Pears 56 Persimmons 28	High	Pears, persimmon (long-tailed mealybug only)
Chlorpyrifos (PER14547, expires 31.8.24)	1B	14	High	Persimmons
Clothianidin (Samurai®)	4A	7	High	Apples, pears
Clothianidin (Samurai®, PER14779, expires 31.1.26)	4A	Not required when used as directed	High	Persimmons
Flonicamid (Mainman®)	29	21	Low	Apples (tuber mealybug), pears (long-tailed mealybug)
Flonicamid (Mainman®, PER89215, expires 31.5.28)	29	21	Low	Persimmons
Potassium salts of fatty acids (Hitman®)	Bio-pesticide	Not required when used as directed	Unknown	Fruit trees
Prothiofos (Tokuthion®)	1B	56	Medium	Pears
Spirotetramat (Movento®)	23	21	Medium	Pome fruit, stone fruit
Sulfoxaflor (Transform® Isoclast™)	4C	7	Medium	Pome fruit
Sulfoxaflor (PER87067, expires 30.4.24)	4C	7	Medium	Persimmons

[1] WHP = withholding period. [2] Always refer to the label.

Oriental fruit moth

Grapholita molesta

Introduced to Australia at the beginning of the 20th century, the oriental fruit moth (OFM) is primarily a pest of stone fruit, but can occasionally infest apples and pears.

Risk period

Table 39. The peak risk period for oriental fruit moth.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Oriental fruit moths are small, grey–brown and approximately 5–7 mm long (Figure 102). Although rarely seen in the orchard during the day, they might be seen near the 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 that can be found under the bark or in tree wounds, particularly around the lower tree trunk.

Figure 102. 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 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 103). 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 104).

Figure 103. 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 estimate 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 as the basis for calculating degree days and predicting first generation egg hatch. For more information, see Calculating degree days for temperate fruit moth pests on page 94. Regularly inspecting shoots and fruit will help identify the early stages of any OFM infestations. Look for dying shoot tips and/or gummy exudate on fruit.

Figure 104. 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.

Management

Cultural and physical

Good orchard management will help with OFM control. Smooth-barked, calm, 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 burnt.

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 105).

Figure 105. *Trichogramma* spp. wasps can parasitise oriental fruit moth eggs and can be purchased for release.

Chemical

Table 40. Registered or permitted products for oriental fruit moth in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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
Clothianidin (Samurai®, PER13527, expires 30.6.26)	4A	21	High	Apricots
Cydia pomonella granulosis virus (Grandex®)	Biological insecticide	0	Low	All crops[3]
Indoxacarb (Avatar® eVo)	22A	7	Low	Apricots, nectarines, peaches, plums
Maldison (Hy-Mal®)	1B	3	High	Stone fruit
OFM mating disruptant	Pheromone	0	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 (Calypso®)	4A	Stone fruit except peaches 14 Pome fruit and peaches 21	Medium	Pome fruit, stone fruit

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

Oystershell scale

Diaspidiotus ostreaeformis

Oystershell scale is a small insect that attaches itself to bark and causes damage by feeding on the trunk and branches of fruit trees. This is a relatively uncommon pest in NSW temperate fruit orchards.

Risk period

Table 41. The peak risk period for oystershell scale.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

The covering of the female oystershell scale is usually around 4 mm long, elongated and tapers to a point (Figure 106). They are often slightly curved, resembling an oyster shell. They are usually brown with waxy scales that are cream on the underside. They have short antennae but no eyes or legs.

Figure 106. Oystershell scale infestation. Photo: Rosa Henderson, New Zealand Biosecurity.

Damage

Oystershell scale feed on the trunks and branches of fruit trees, killing the areas at the feeding site. Heavy infestations will reduce growth, cause foliage yellowing and bark cracking, and can even lead to plant death.

Monitoring

Monitor branches for oyster-shell shaped bumps and yellowing leaves to determine the correct timing for control, which will reduce oystershell scale populations.

Management

Cultural and physical

Strong, healthy plant growth can reduce the likelihood of scale infestations. On young trees, old scale covering and eggs can be destroyed by scrubbing the bark. Heavily infested branches should be pruned.

Biological

Oystershell scale has very few natural predators for control. Parasitic wasps and predatory mites have been observed to feed on overwintering eggs, but control levels are minimal.

Chemical

Horticultural mineral oils registered for use against oystershell scale (Table 42) vary in their suitability for use as a summer or winter treatment. Discuss product choice and correct time of use with your chemical supplier and always consult the product label.

Table 42. Registered product for oystershell scale in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Horticultural mineral oil (various)	Paraffinic oil and petroleum oil	1	Low	Pome fruit, stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

Pear and cherry slug

Caliroa cerasi

The pear and cherry slug is the larval stage of the sawfly *Caliroa cerasi*. It is predominantly a pest of pear and cherry trees.

Risk period

Table 43. The peak risk period for pear and cherry slug.

Budswell/ 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 slug or leech-like larvae approximately 5–10 mm long (Figure 107).

Damage

The larvae damage pear and cherry trees by feeding on the upper surfaces of leaves, resulting in 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 whole of the tree canopy can brown-off prematurely.

Figure 107. A leaf that has typical feeding damage from pear and cherry slug, which is also present.

Monitoring

Keep an eye out for pear and cherry slug activity while working in the orchard throughout the season. Early detection can help prevent significant 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 your orchard will help control.

Chemical

The chemical options for controlling pear and cherry slug are listed in Table 44.

Table 44. Registered or permitted products for pear and cherry slug in NSW.

Active constituent (example trade name)	Insecticide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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, nectarine, peaches, plums
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

[1] WHP = withholding period. [2] 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 45. The peak risk period for pear leaf blister mite.

Budswell/ 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 observe 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, eventually becoming brown dead spots (Figure 108). Infested fruit will have depressed, russeted spots.

Figure 108. Pear leaf blister mite leaf damage.

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 46) for pear leaf blister mites should be based on the results of regular mite monitoring.

Table 46. Registered or permitted products for pear leaf blister mite in NSW.

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

[1] WHP = withholding period. [2] Always refer to the label.

Plague thrips

Thrips imaginis

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

Risk period

Table 47. The peak risk period for plague thrips.

Budswell/ 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 109). They are usually brown, narrow-bodied and about 1.0–1.3 mm long.

Figure 109. Plague thrips adult on a flower stamen.

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 110).

Monitoring

Monitor for plague thrips using yellow sticky traps (Figure 111) placed throughout the orchard from budburst to shuckfall. The traps can indicate thrips activity levels and can also be used to obtain a formal identification of the pest species.

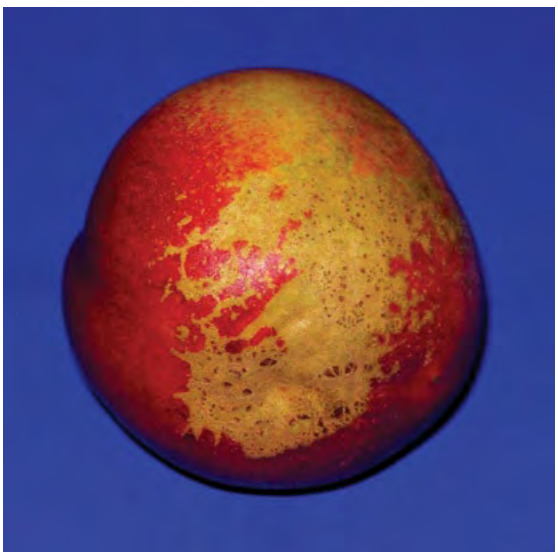


Figure 110. Fruit russet caused by early thrips feeding on the fruitlet.

Figure 111. 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. numbers/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 drive 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 full 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 48) 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 48. Registered or permitted products for plague thrips in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + novaluron (Cormoran®)	4A + 15	70	Medium	Apples
Bifenthrin (Talstar® 80 SC)	3A	0	High	Apples
Flonicamid (Mainman®, PER89215, expires 31.5.28)	29	21	Low	Persimmons; suppression only
Maldison (Hy-Mal®)	1B	3	High	Apples, pears
Methomyl (Methomyl 225)	1A	1	High	Stone fruit
Methomyl (PER14548, expires 31.7.28)	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
Pyrethrins/piperonyl butoxide (Py-Bo)	3A	1	High	All crops[3]
Tau-fluvalinate (Mavrik® Aquaflow)	3A	Not required when used as directed	High	Apples, cherries, nectarines, peaches, plums

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

Queensland fruit fly

Bactrocera tryoni

Queensland fruit fly (QFF) is a significant pest of temperate fruit crops throughout northern and eastern Australia, including coastal and warm inland districts. It is an important quarantine pest of particular concern to most importing countries.

Risk period

Table 49. The peak risk period for Queensland fruit fly.

Budswell/ 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 112). Queensland fruit fly 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 fly 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 113).

When the eggs hatch, the developing larvae burrow into the fruit causing the flesh to decay (Figure 114). In many instances, the affected fruit will look intact from the outside.

Figure 112. Dorsal view of an adult Queensland fruit fly.

Figure 113. Multiple Queensland fruit fly stings to an apple.

Figure 114. Queensland fruit fly larvae (maggots) and typical 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 115), Bugs for Bugs, Bio-Trap, Eco-Lure, Probodelt Cone and McPhail.

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 51). Consult your trap supplier for further advice.

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 116) are also available as non-spray tools to manage adult QFF numbers.

Figure 115. A Lynfield trap.

Figure 116. 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.

Biological

Queensland fruit fly has several natural predators including the parasitoid *Diachasmimorpha tryoni*. Although not commercially available for release, studies have investigated using *D. tyroni* as part of an integrated management program.

Sterile insect technique (SIT) involves the mass rearing and sterilisation of 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 (and Table 51).

Table 50. Registered or permitted **sprays** for Queensland fruit fly in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + novaluron (Cormoran®)	4A + 15	7	Medium	Stone fruit; suppression only
Acetamiprid + pyriproxyfen (Trivor®, PER89943, expires 31.1.24)	4A + 7C	28	Unknown	Persimmons; suppression only
Alpha-cypermethrin (PER91059, expires 30.6.27)	3A	7	High	Stone fruit except cherries
Clothianidin (Samurai®)	4A	7	High	Pome fruit, stone fruit, persimmons
Dimethoate (PER13859, expires 31.7.24)	1B	Do not harvest sprayed fruit	High	Fruit fly host plants; postharvest use only
Etofenprox (Trebon®)	3A	3	High	Stone fruit except cherries
Maldison (Fyfanon® 440 EW)	1B	3	High	Apples, pears, stone fruit, persimmons

Table 50. Registered or permitted **sprays** for Queensland fruit fly in NSW, page 2.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Pyrethrins (Pyganic®)	3A	Stone fruit 0 Cherries 1	High	Stone fruit including cherries; preharvest clean-up spray only
Spinetoram (PER12590, expires 31.5.24)	5	Pome fruit 7 Stone fruit 3	Medium	Pome fruit, stone fruit; suppression only
Trichlorfon (Lepidex®)	1B	2	High	Pome fruit, stone fruit
Trichlorfon (PER12450, expires 30.11.25)	1B	2	High	Persimmons

Table 51. Registered or permitted **baits and lures** for Queensland fruit fly in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Chlorpyrifos (Chlorpyrifos 750 WG) + yeast hydrosylate	1B	14	Medium when used as bait	Stone fruit; female and male spray bait
Fipronil + 4-(p-acetoxyphenyl)-2-butanone (Amulet Cue-Lure®)	2B	Not required when used as directed	Low when used as bait	Male attract and kill
Hydroxyphenylbutanone acetate (Fly Bye®)	Lure	Not required when used as directed	Low	Male lure only for traps
Lures, attractants, pheromones and toxicants in traps (PER13785, expires 30.4.24)	Various	Not required when used as directed	Low	Various
Maldison (Hy-Mal®)	1B	Not required when used as directed	Low when used as bait	Female and male attract and kill lure
Maldison + 4-(p-acetoxyphenyl)-2-butanone (Eco-Lure®)	1B	Not required when used as directed	Low when used as bait	Male attract and kill
Spinosad (Naturalure®)	5	Not required when used as directed	Low	Fruit crops; attract and kill bait

[1] WHP = withholding period. [2] Always refer to the label.

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 toxicant at the label rate

How to apply

- Apply fresh on day of mixing
- Use 15 L of mixture per ha
- Apply as a spot or band to the host plants or 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 don't 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 may 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 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 hook through lid into pheromone wick holder
- Insert 4 plastic entry ports into side of 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 host tree/crop shaded from direct sunlight
- Empty traps and record fly catches at least weekly
- Replace 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

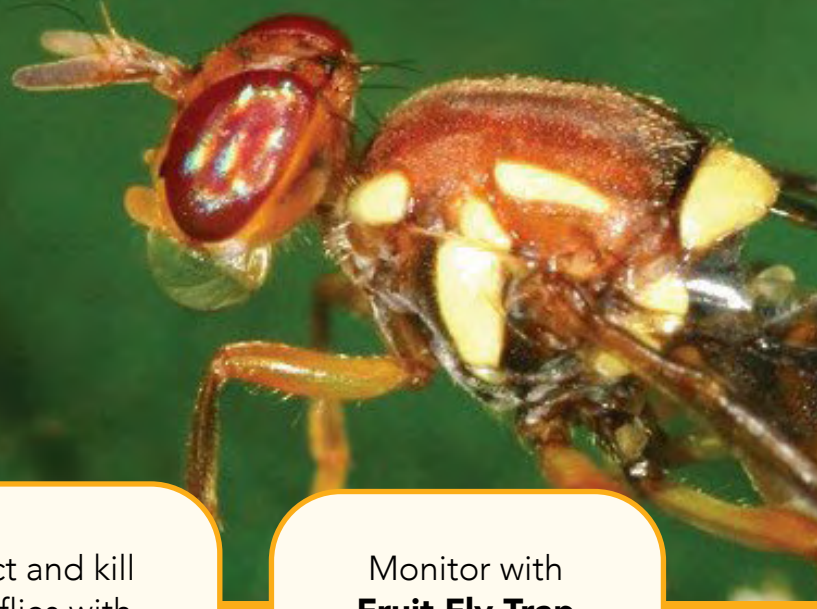
Contact us for more information about fruit fly management

Phone: 07 4646 2628 E-mail: info@bugsforbugs.com.au Website: www.bugsforbugs.com.au

Fighting fruit fly?

BUGS FOR BUGS

Bugs for Bugs
has you covered
with powerful tools
backed by
expert advice



Attract and kill female flies with **Fruit Fly Lure** protein bait

Attract and kill male flies with **MAT cups**

Monitor with **Fruit Fly Trap Pro**

Scan this QR code to access our practical **Fruit Fly Toolkit**

For more information visit our website **www.bugsforbugs.com.au**

Or call **David Loxley** 0459 974 960

Rutherglen bug

Nysius vinitor

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

Risk period

Table 52. The peak risk period for Rutherglen bug.

Budswell/ 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 117). They are highly mobile and often swarm over the fruit and shoot surfaces in the hundreds (Figure 118).

Figure 117. Adult Rutherglen bug.

Figure 118. Rutherglen bug swarm on an apple.

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 fruits, 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. More intense monitoring should occur if canola or sorghum in surrounding areas is infested.

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 (see Managing weeds on page 139).

Biological

Birds and spiders might provide some predation of Rutherglen bug, but this will not provide control of large populations.

Chemical

Table 53. Registered or permitted products for Rutherglen bug in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Maldison (Fyfanon® ULV)	1B	3	High	Stone fruit
Pyrethrins (Pyganic®)	3A	Cherries 1 Apricots, nectarines, peaches, plums, prunes 0	High	Stone fruit
Trichlorfon (Dipterex®)	1B	2	High	Pome fruit, stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

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 54. When to monitor and manage for San José scale.

Budswell/ green tip	Blossom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

San José scale adult females are yellow with rounded dark grey scales (Figure 119). They are wingless and legless, measuring 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.

Figure 119. San José scale adult. Photo: United States National Collection of Scale Insects Photographs, USDA Agricultural Research Service, Bugwood.org.

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 120). If populations are low, the damage will be concentrated on the bottom of the fruit.

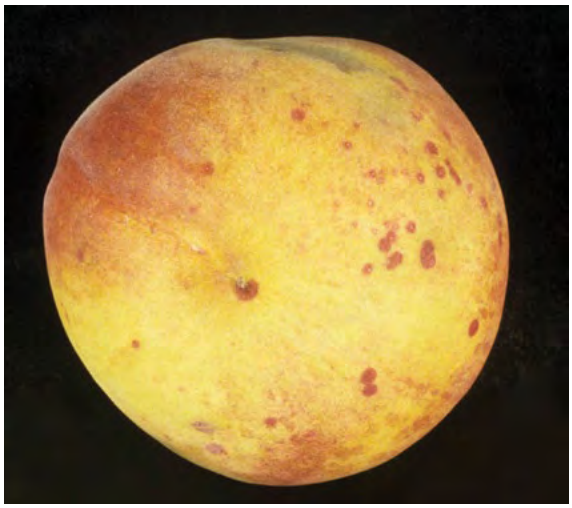


Figure 120. San José scale on a peach.

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 overwinter as immature scales. 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. Dormant season treatments are the most effective.

Cultural and physical

The most effective cultural control is to prune out infested branches. This will reduce scale numbers and open up the tree canopy, improving spray penetration and coverage. Control ant populations (see page 29) as they spread the scale 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

There are several natural predators that 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*). A range of fungi and bacteria is available that can infect and kill scale insects, however, these are less likely to reduce populations unless they become very abundant. It should be noted that almost all pesticides for SJS control will negatively affect beneficial insect populations.

Chemical

The chemical options for controlling SJS are listed in Table 55.

Table 55. Registered or permitted products for San José scale in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + novaluron (Cormoran®)	4A + 15	Apples 70 Pears 35 Stone fruit 7	Medium	Apples, pears, stone fruit
Chlorpyrifos (Strike-Out® 500 EC)	1B	14	High	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®)	23	21	Medium	Pome fruit, stone fruit
Sulfur (S) as polysulfide sulfur (Grochem® Lime Sulphur)	M2	Not required when used as directed	Medium	Pears, apricots, nectarines, peaches, plums, prunes; stone fruit dormant to budswell spray only
Sulfoxaflor (Transform® Isoclast™)	4C	7	Medium	Pome fruit

[1] WHP = withholding period. [2] Always refer to the label.

Two-spotted mite

Tetranycus urticae

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

Risk period

Table 56. The peak risk period for two-spotted mite.

Budswell/ 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 121). Adult males are smaller and less distinctive than females. Eggs are also opaque, cream and very small, about 0.1 mm (Figure 122). TSM activity is often associated with webbing over the affected foliage.

Figure 121. Two-spotted mite adults.

Figure 122. Juvenile two-spotted mites with eggs on an apple leaf.

Damage

TSM damage 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. Two-spotted mites should not be confused with other orchard pest mites such as European red mite (page 53) or Bryobia mite (page 37). 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 seem to prefer dusty conditions and often thrive 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.

Figure 123. The predatory mite *Phytoseiulus persimilis* attacking two-spotted mites.

Biological

The predatory mites *Galendromus occidentalis* (formerly *Typhlodromus occidentalis*), *Phytoseiulus persimilis* (Figure 123) and *Neoseiulus californicus* can be very 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 off by sprays used for other orchard pests.

Chemical

Decisions to spray for TSM are best made based on the results of regular monitoring. Effective mite control spray programs usually incorporate a single horticultural mineral oil during winter or just before budburst. The chemical options for controlling TSM are in Table 57.

Table 57. Registered or permitted products for two-spotted mite in NSW.

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

[1] WHP = withholding period. [2] Always refer to the label.

Weevils

Various species

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

Risk period

Table 58. The peak risk period for weevils.

Budswell/ green tip	Blossom	Mid season	Harvest	Postharvest	Dormancy

The most potentially damaging weevils are:

- Apple weevil (*Otiorynchus cribricollis*)
- Eucalyptus weevil (*Gonipterus scutellatus;* Figure 124).
- Fuller's rose weevil (*Asynonychus cervinus;* Figure 125)
- Fruit tree root weevil (*Leptopius robustus;* Figure 126)
- Garden weevil (*Phlyctinus callosus;* Figure 127)

Pest identification

Weevils are small beetles that have snouts, a set of antenna, 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 124. Eucalyptus weevil. Photo: William M. Ciesla, Forest Health Management International, Bugwood.org.

Figure 125. Fuller's rose weevil.

Figure 126. Fruit tree root weevil. Photo: Pest and Diseases Image Library, Bugwood.org.

Figure 127. Garden weevil. Photo: Pest and Diseases Image Library, Bugwood.org.

Damage

Weevils damage the fruit, leaves and roots of fruit trees (Figure 128). Feeding on fruit causes scarring, making it unsuitable for the fresh market. Weevils feeding on leaves can excrete 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 a host for weevils to lay eggs and provide an alternative feeding site. Maintaining a clean weed strip and having a mown inter-row (Figure 129) will reduce the number of weevils in the orchard.

Figure 128. Fullers rose weevil damage to apple leaves.

Figure 129. 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, decreasing the number of weevils in the orchard.

Chemical

Table 59. Registered or permitted products for weevils in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Alpha-cypermethrin (Astound® Duo)	3A	14	High	Pome fruit for apple weevil and garden weevil
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

[1] WHP = withholding period. [2] Always refer to the label.

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 60. The peak risk period for western flower thrips.

Budswell/ green tip	Blossom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Adult western flower thrips (WFT) are pale brown–yellow, with narrow bodies (Figure 130) 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. To properly identify the pest thrips in your orchard, consider trapping and sending samples of the thrips to an accredited laboratory such as the NSW DPI Plant health diagnostic service (https://www.dpi.nsw.gov.au/about-us/services/laboratory-services/plant-health).

Figure 130. Adult western flower thrips.

Damage

WFT damages the skin of certain temperate fruits including apples and nectarines by feeding on the fruit surface. As the damaged skin cells grow, the injury develops into a russet (Figure 131), or in apples, the fruit develops an unusual pansy flower-shaped spot (Figure 132).

Figure 131. Western flower thrips feeding damage on a nectarine.

Figure 132. Pansy spot caused by western flower thrips.

Monitoring

Monitor for thrips species using yellow sticky traps (Figure 133) hung throughout the orchard from budburst to harvest. The traps will give an indication of thrips activity and can also be sent to a laboratory to obtain a formal identification of the pest species.

Figure 133. Use sticky traps to monitor for various thrips 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 broadleaved weeds (particularly clover) are an alternative host for WFT, keep ground covers 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 full control of WFT.

Chemical

Registered or permitted chemical options for the control of WFT (Table 61) are limited and differ from those used to manage plague thrips (page 72), therefore correctly identifying the pest thrips species is vital.

Table 61. Registered or permitted products for western flower thrips in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Flonicamid (Mainman®, PER89215, expires 31.5.28)	29	21	Low	Persimmons; 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 28.2.24)	23	21	Medium	Stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

Wingless grasshoppers

Phaulacridium vittatum

The wingless grasshopper is native to Australia and can be a problem in all growing regions.

Risk period

Table 62. The peak risk period for wingless grasshoppers.

Budswell/ 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 134). 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 34), wingless grasshopper populations are usually localised and do not form large migratory swarms.

Figure 134. 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

Orchard weeds 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 63.

Table 63. Registered or permitted products for wingless grasshoppers in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Carbaryl (Bugmaster®)	1A	Pome fruit 77 Stone fruit 35	High	Pome fruit, stone fruit; do not use on cherries
Chlorpyrifos (Strike-Out® 500 EC)	1B	14	High	Apples, pears
Fenitrothion (Sumithion® ULV)	1B	14	High	Apples, cherries
Indoxacarb (Avatar® eVo)	22A	Apricots, nectarines, peaches, plums 7 Apples, pears, cherries 14	Low	Apples, pears, apricots, cherries, nectarines, peaches, plums

[1] WHP = withholding period. [2] Always refer to the label.

Woolly apple aphid

Eriosoma lanigerum

Woolly apple aphids (WAA) are a serious pest of apple trees. They can also affect pear trees.

Risk period

Table 64. The peak risk period for woolly apple aphid.

Budswell/ green tip	Blossom	Mid season	Harvest	Postharvest	Dormancy

Pest identification

Woolly apple aphids are most conspicuous during the growing season when they cluster in white woolly colonies on young green shoots (Figure 135) 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.

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 potential yield and normal tree growth. Damage to root systems (particularly on young trees) can be extensive and result in root death and reduced tree growth.

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

Monitoring

Woolly apple aphid management should be guided by the results of regular pest monitoring and 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 in-season inspections, keep an eye out for signs of parasitism (Figure 136).

Figure 135. Woolly apple aphid colonies on an apple tree.

Figure 136. Parasitised woolly apple aphid adults with some showing exit holes from where the mature wasp has emerged. Photo: R Kerrison.

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 137) and lacewing larvae (see Protecting 'beneficials' on page 96) are useful natural WAA predators and can 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 body will emerge by chewing a circular hole in the aphid's abdomen (Figure 136).

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.

Figure 137. Lady beetles feeding on woolly apple aphid and galls caused by the aphids.

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. Control of 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 absolutely necessary (Table 65).

Table 65. Registered or permitted products for woolly apple aphid in NSW.

Active constituent (example trade name)	Insecticide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Acetamiprid + novaluron (Cormoran®)	4A + 15	Apples 70 Pears 35	Medium	Apples, pears; suppression only
Chlorpyrifos (Strike-Out® 500 EC)	1B	14	High	Apples, pears
Clothianidin (Samurai®)	4A	7	High	Apples; foliar spray or soil drench
Flonicamid (Mainman®)	29	21	Low	Apples
Imidacloprid (Confidor® 200 SC)	4A	Not required when used as directed	Medium	Apples
Maldison (Hy-Mal®)	1B	3	High	Pome fruit
Pirimicarb (Pirimor®)	1A	2	Medium	Apples
Spirotetramat (Movento®)	23	21	Medium	Pome fruit; suppression only
Sulfoxaflor (Transform® Isoclast™)	4C	7	Medium	Pome fruit

[1] WHP = withholding period. [2] Always refer to the label.
Note: Thiacloprid (Calypso®) 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?

Insect development is temperature-driven. 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 that 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 typically 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 the grower to 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 the 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, but budbreak 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 do 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 DD from biofix

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

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

Example calculation

For codling moth (with a lower developmental threshold of 10 °C; Table 66) on a day where the daily maximum temperature was 18 °C and the minimum 7 °C, the DD for that day would be 2.5, calculated as follows:

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

$$DD = 25 \div 2 - 10$$

$$DD = 12.5 - 10$$

$$DD = 2.5$$

The lower developmental thresholds for CM, LBAM and OFM are listed in Table 66.

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 (Figure 138) to ensure accurate measurement of ambient temperature, which can be recorded in a spreadsheet or on paper. Some weather stations with inbuilt models will track DD accumulation and predict first spray timing. Table 67 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 occurs 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 66. 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 67. 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 138. A Stevenson screen is the recommended housing for temperature recording in the orchard.

Protecting 'beneficials'

Modern orchard crop protection programs employ an integrated pest and disease management (IPDM) approach, using a combination of available tools including 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 more important.

Orchard IPDM programs should minimise synthetic chemical use by only using them when necessary, accurately targeting their use and only using the least disruptive chemical that will do the job. Preferencing IPDM-friendly chemistry in a program will help optimise beneficial insect numbers in the orchard, allowing nature to make a useful contribution to controlling the target pest or disease.

Important beneficial insects found in temperate fruit orchards include lady beetles, lacewings, parasitic wasps, predatory mites, *Stethorus* beetles and European earwigs.

Some examples include:

- lady beetles (adult and larvae; Figure 139) are predators of aphids, mealybugs, scale insects and pest mites
- lacewing (Figure 140) larvae will control mealybugs, aphids, whitefly, scale, pest mites and moth eggs
- parasitic wasps (including *Trichogramma* spp.) lay their eggs in aphids, mealybugs, *Helicoverpa*, borer moths, codling moths, light brown apple moths, oriental fruit moths and looper caterpillars (Figure 141)
- predatory mites (Figure 142), either native or introduced, prey on pest mites (including *Bryobia* mite, two-spotted mite and European red mite) and thrips (including WFT).

Figure 139. Lady beetle. Photo: David Cappaert, Michigan State University, www.msu.edu.

Figure 140. Lacewing adult. Photo: Joseph Berger, www.forestryimages.org.

Figure 141. Parasitic wasp. Photo: Scott Bauer, USDA Agricultural Research Service, www.forestryimages.org.

Figure 142. Predatory mite.

Monitoring pest and beneficial populations throughout the growing season is an important component of any IPDM program. Knowing the current status of any pest or beneficial population can greatly improve the ability to run an effective 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. Know your orchard pests and beneficial insects and mites and be able to recognise them. Reference material is available in *The good bug book* (bugsforbugs.com.au/product/good-bug-book-cd/)
2. Monitor your orchard pests, beneficial insects and predatory mites to effectively time sprays.
3. Use chemicals less toxic to beneficials (Table 68). Consult the chemical label or the Good bug website (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.

For further resources visit The Good bug website (www.goodbugs.org.au/)

Suppliers of beneficial insects and mites can be found at www.goodbugs.org.au/suppliers.html.

Table 68. Pesticides toxic to predatory mites, lady beetles and lacewings.

Pesticides	*Phytoseiulus persimilis*	*Galendromus occidentalis*	*Galendromus pyri*	Lady beetles	Lacewings
Insecticides					
Bifenthrin	XX	XX	XX	–	–
Carbaryl	0	X	0	XX	XX
Chlorpyrifos	X	X	0	XX	XX
Maldison	X	X	X	XX	XX
Methomyl	XX	X	XX	X	X
Tau-fluvalvinate	XX	XX	XX	–	–
Trichlorfon	XX	0	?	–	–
Miticides					
Abamectin	X	X	X	X	XX
Tebufenpyrad	XX	0	0	–	–
Fungicides					
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.
Only those recommended in this guide are included.
For more extensive information on chemicals, see the Good bug website (www.goodbugs.org.au/chemicals.html).

Diseases

Alternaria leaf blotch and fruit spot

Alternaria species

Alternaria leaf blotch and fruit spot mainly affect apples, and can be particularly damaging in warm growing regions with high summer rainfall.

Risk period

Table 69. The peak risk period for alternaria leaf blotch and fruit spot.

Budswell/ 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 143). 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 144), often surrounded by a black border. Fruit spotting is commonly observed in late summer through to harvest.

Figure 143. Alternaria leaf blotch on apple leaves.

Figure 144. Alternaria fruit spot on an apple.

Damage

In favourable weather conditions, the alternaria leaf blotches will continue to grow, and when the leaf is half covered by lesions, it will turn yellow (Figure 145) 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), it is important to have symptoms assessed by an expert, especially

Figure 145. Leaf yellowing from alternaria leaf blotch.

if considering applying fungicides (or other treatments) to combat this disease.

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, Pink Lady and Red Delicious.

Figure 146. The 'Sadie' sweeper in action moving leaf and pruning residue to the centre of the row for mulching Photo: Crendon Machinery.

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 commercial-sized orchards, mechanised sweeping (Figure 146) and mulching is a more cost-effective way to hasten 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 70.

Table 70. Registered or permitted products for alternaria leaf blotch and fruit spot in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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 Fungicide)	M3	14	Medium	Apples
Polyoxin D zinc salt (Intervene® WG Fungicide)	19	Not required when used as directed	Low	Apples

[1] WHP = withholding period. [2] Always refer to the label.

Angular leaf spot

Cercospora species and *Pseudocercospora* species

Risk period

Table 71. The peak risk period for angular leaf spot in persimmons.

Budswell/ green tip	Shoot extension	Flowering and fruit development	Harvest	Postharvest	Dormancy

Disease identification

The word angular in the common name for this disease refers to the straight-edged leaf spots that are found on infected persimmon foliage (Figure 147). 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 key pathogen in persimmons, *Mycosphaerella* spp. (page 111) which results in similar leaf spots, but with round margins.

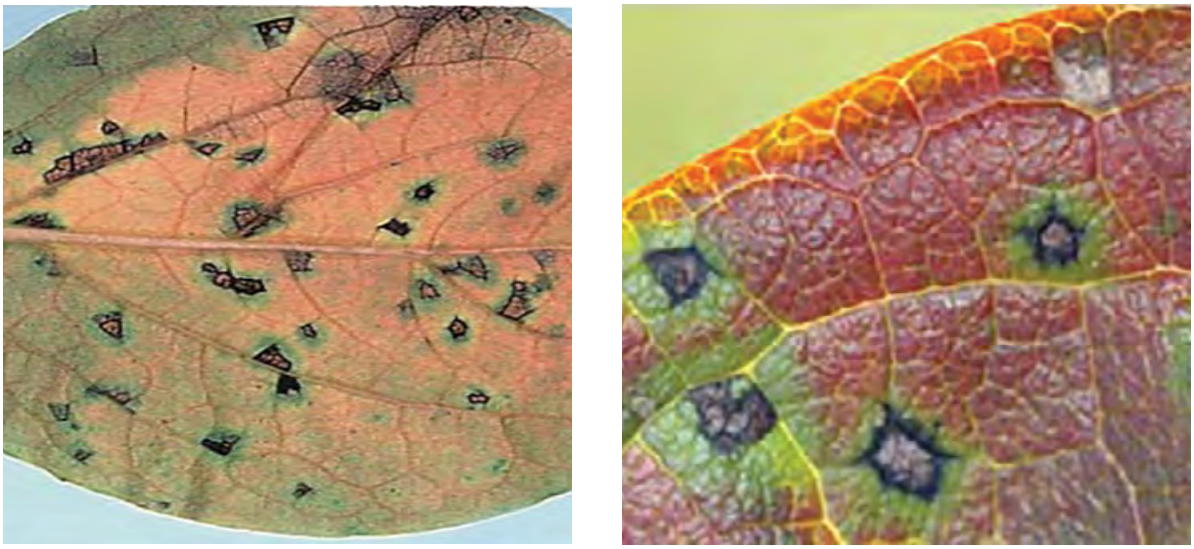


Figure 147. Angular leaf spot on persimmon leaves, showing characteristic angular lesions. Photo: *Integrated Pest and Disease Management Manual for Persimmons* 2017 (Queensland Government, Hort Innovation Persimmon Fund).

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 the infections become 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 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

Table 72 lists chemicals currently registered or permitted for managing angular leaf spot in NSW persimmon orchards.

Table 72. Registered or permitted products for angular leaf spot in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Chlorothalonil (PER13445, expires 31.7.25)	M5	7	Low	Persimmons
Difenoconazole (PER87599, expires 30.6.24)	3	28	Low	Persimmons
Mancozeb (PER12488, expires 31.3.25)	M3	14	Medium	Persimmons

[1] WHP = withholding period. [2] Always refer to the label.

Apple scab and pear scab

Venturia inaequalis and *Venturia pirina*

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 73. The peak risk period for apple scab and pear scab.

Budswell/ 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 148) 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 149 and Figure 150).

Figure 148. Primary scab infection on an apple leaf.

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 149. Scab lesions on an apple.

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 first week of December in most districts).

Figure 150. Scab lesions on a pear. Photo: Bruce Watt, University of Maine, Bugwood.org.

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.

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 for this disease. Consult your fruit nursery supplier for information on resistant varieties.

Chemical

Chemical spray programs (Table 74) 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 then, the potential for secondary infections through the rest of the growing season is dramatically reduced.

Table 74. Registered or permitted products for apple scab and pear scab in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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 (Hostile 50SC)	C	Apples 7; Pears 14	Low	Apples, pears
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 (Systhane® 400 WP)	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 (S) 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 (Thiragranz®)	M3	7	Low	Apples, pears
Trifloxystrobin (Flint®)	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

[1] WHP = withholding period. [2] Always refer to the label.

Bacterial canker

Pseudomonas syringae pv. *syringae*

Bacterial canker can affect all parts of stone fruit trees, with cherries and apricots the most susceptible.

Risk period

Table 75. The peak risk period for bacterial canker.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Trees infected with bacterial canker will have dead bark and when the sunken surface bark is removed, the underlying tissue will be orange–brown (Figure 151). Large amounts of gum can exude from the trunk and bark cankers (Figure 152). The infection first appears on the leaves as water-soaked spots, which can turn brown and fall out as the leaves age (Figure 153). They 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.

Figure 151. Bacterial canker on an apricot tree.

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.

Figure 152. Bacterial canker on a cherry tree.

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 budburst 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.

Figure 153. Bacterial canker on cherry leaves.

Avoid damage to trees, particularly during winter. 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 76.

Table 76. Registered product for bacterial canker in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Bacillus amyloliquefaciens (Serenade® Opti Biofungicide, PER88559, expires 31.8.24)	44	Not required when used as directed	Low	Cherries; suppression only
Copper-based fungicides (various)	M1	1	Low	Apricots, cherries, stone fruit
Copper hydroxide + mancozeb (ManKocide®)	M1 + M3	14	Medium	Stone fruit

[1] WHP = withholding period. [2] 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 77. The peak risk period for bacterial spot.

Budswell/ 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 154). 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 155).

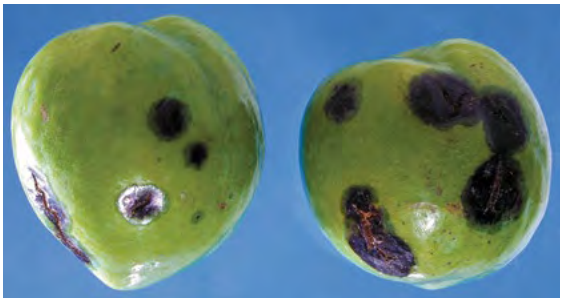


Figure 154. Bacterial spot on plums.

Figure 155. Bacterial spot in stone fruit. Photo: University of Georgia Plant Pathology, Bugwood.org.

Damage

Up to half the fruit can become unsaleable due to cosmetic damage. Extensive leaf spotting results in ripping and tattering of foliage.

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 peaches and nectarine leaves and fruit. Windy, wet conditions and heavy dews during the growing season will also favour secondary infections. Extra caution is recommended during these conditions.

Management

Cultural and physical

Trees suffering from other pests and diseases 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

Chemical control options for bacterial spot in NSW are limited (Table 78). 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 78. Registered product for bacterial spot in NSW.

Active constituent (example trade name)	Fungicide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Bacillus amyloliquefaciens (Serenade® Opti Biofungicide, PER88559, expires 31.8.24)	44	Not required when used as directed	Low	Cherries
Copper oxychloride (Coppox®)	M1	1	Low	Stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

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 79. The peak risk period for bitter rot.

Budswell/ 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 156). 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 156. 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 has been some research into using yeasts and bacteria as biological control agents, however, none have been developed for commercial use.

Chemical

The chemical options for controlling bitter rot are listed in Table 80.

Table 80. Registered or permitted products for bitter rot in NSW.

Active constituent (example trade name)	Fungicide group	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Copper oxychloride (Coppox®)	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

[1] WHP = withholding period. [2] 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 81. The peak risk period for blossom blight and brown rot.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy
	Blossom blight	Brown rot			

Disease identification

Blossom blight results in brown, shrivelled, dead flowers (Figure 157) 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 158 and Figure 159).

Infected fruit will sometimes shrivel and hang on the tree. These mummified (or mummy) fruit (Figure 160) and infected shoots are a major source of carryover spores for the next season and should be removed from the orchard.

Figure 157. A peach flower infected by blossom blight. Photo: University of Georgia Plant Pathology, University of Georgia, Bugwood.org.

Figure 158. Peach fruit showing typical brown rot infection. Photo: Rebecca A Melanson, Mississippi State University Extension, Bugwood.org.

Figure 159. Brown rot on cherries.

Figure 160. Mummified fruit. Photo: Clemson University, USDA Cooperative Extension Slide Series, Bugwood.org.

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. 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 when 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

There has been some research into the effects of antagonistic yeasts as a potential biocontrol for *Monilinia* species in stone fruits. However, there are currently no commercially available treatments. The plant protein-based biological fungicide, Problad Plus®, has label registration for suppression of brown rot and blossom blight in stone fruit (Table 82).

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 budburst through flowering and to harvest, depending on weather conditions and disease pressure. Postharvest chemical options are also included in Table 82. For more information on managing storage rots, including brown rot, see Managing postharvest diseases and disorders on page 129.

Table 82. Registered or permitted products for blossom blight and brown rot in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in[2]*…
Bacillus amyloliquefaciens (Serenade® Opti Biofungicide, PER88559, expires 31.8.24)	44	Not required when used as directed	Low	Cherries; suppression only
BLAD (ProBlad®)	BM01	Not required when used as directed	Low	Stone fruit; suppression only
Captan (Captan®)	M4	7	Low	Stone fruit except apricots
Chlorothalonil (Bravo Weather Stik®)	M5	Apricots, cherries, nectarines, peaches 7 Plums 1	Low	Apricots, cherries, nectarines, peaches, plums
Copper oxychloride (Coppox®)	M1	1	Low	Stone fruit
Cyprodinil (Chorus®)	9	Not required when used as directed	Low	Apricots, nectarines, peaches, plums
Dithianon (Dinon 700 WG)	M9	21 Canning peaches 1	Low	Apricots, cherries, nectarines, peaches, plums, prunes

Table 52. Registered or permitted products for blossom blight and brown rot in NSW, page 2.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in[2]*…
Dodine (Syllit®)	U12	Not required when used as directed	Low	Nectarines, peaches; do not apply after petal fall
Fludioxonil (Fludy®)	12	Not required when used as directed	Low	Stone fruit
Fluopyram + trifloxystrobin (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 (Rovral Aquaflo®)	2	0	Low	Stone fruit; orchard spray and postharvest dip
Mancozeb (Dithane® Rainshield® NeoTec®)	M3	14	Medium	Stone fruit
Mandestrobin (Intuity™)	11	7	Low	Stone fruit
Penthiopyrad (Fontelis®)	7	Not required when used as directed	Low	Stone fruit
Potassium bicarbonate + potassium silicate (Ecocarb® Plus)	M2	Not required when used as directed	Low	Nectarines
Procymidone (Sumisclex® 500)	2	9	Low	Stone fruit
Propiconazole (Tilt® 500 EC)	3	1	Low	Stone fruit
Pyraclostrobin + fluxapyroxad (Merivon®)	7 + 11	2	Low	Cherries
Sulfur (S) as polysulfide sulfur (Grochem® Lime Sulphur)	M2	Not required when used as directed	Medium	Stone fruit (dormant to budswell spray only)
Sulfur (Thiovit Jet®)	M2	Not required when used as directed	Medium	Nectarines, peaches, plums
Thiram (Thiragranz®)	M3	7	Low	Stone fruit
Triforine (Saprol®)	3	0	Low	Apricots, nectarines, peaches, plums, prunes; orchard spray and postharvest dip
Ziram (Ziram WG)	M3	7	Low	Cherries, nectarines, peaches

[1] WHP = withholding period. [2] 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 correct product choice.

Circular leaf spot

Mycosphaerella species

Risk period

Table 83. The peak risk period for circular leaf spot in persimmons.

Budswell/ green tip	Shoot extension	Flowering and fruit development	Harvest	Postharvest	Dormancy

Disease identification

Circular leaf spot was first identified in persimmons by NSW DPI in 2003. As the symptoms are similar, this leaf disease is often confused with angular leaf spot, which is also found in persimmons (page 100).

Infected persimmon foliage will have large circular spots with green halos (Figure 161). 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.

Figure 161. Circular leaf spot (*Mycosphaerella* spp.) symptoms on a persimmon leaf. Photo: *Integrated Pest and Disease Management Manual for Persimmons* 2017 (Queensland Government, Hort Innovation Persimmon Fund).

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 the infections become 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 100) might reduce the incidence of this disease.

Crown gall

Agrobacterium tumefaciens

Crown gall is caused by the bacterium *Agrobacterium tumefaciens*. It occurs mostly on stone fruit and some ornamentals, for example roses, but less commonly on pome fruit, grapes and olives.

Risk period

Table 84. The peak risk period for crown gall.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Galls form 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 soil level or on branches. Figure 162 illustrates severe gall infection at the upper crown area on the roots of a peach seedling. 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 162. Crown gall on a peach seedling.

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 method of spread. 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 85.

Table 85. Registered treatment for crown gall in NSW.

Active constituent (example trade name)	Treatment type	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Rhizobium rhizogenes strain K1026 (Nogall®)	Biological	0	Low	Stone fruit

[1] WHP = withholding period. [2] Always refer to the label.

Fly speck

Schizothyrium pomi

Fly speck is a fungal disease that causes surface blemishes on apples and pears, usually late in summer. It is rare in modern commercial orchards where disease management incorporates foliar fungicide sprays.

Risk period

Table 86. The peak risk period for fly speck.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Fly speck is identified by clusters of black, shiny specks on the fruit surface (Figure 163). These specks are round to irregular, and although fly speck can appear separately, it is commonly found in the same conditions that suit sooty blotch development (refer to page 126).

Figure 163. Fly speck on an apple. Photo: Bruce Watt, University of Maine, Bugwood.org.

Damage

Due to its nature, fly speck can shorten the storage life of the fruit due to increased water loss. The saleability of the fruit is reduced due to its unacceptable appearance. In wet years, infected areas can suffer up to 25% loss.

Monitoring

Fly speck can survive from one season to the next on infected branches. The spores are then dispersed during rain in spring and early summer. Monitoring for fly speck should occur when conditions are favourable; i.e. when temperatures are between 18 °C and 27 °C with humidity greater than 90%.

Management

Cultural and physical

This disease can be managed with good orchard maintenance. Pruning to open the canopy will increase light and airflow, reducing the incidence of fly speck.

Biological

There are no biological control measures.

Chemical

The chemical options for controlling fly speck are listed in Table 87.

Table 87. Registered or permitted products for fly speck in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Copper hydroxide + mancozeb (ManKocide®)	M1 + M3	14	Medium	Apples, pears
Mancozeb (Dithane® Rainshield® NeoTec®)	M3	14	Medium	Apples, pears
Metiram (Polyram®)	M3	14	Medium	Apples, pears

[1] WHP = withholding period. [2] Always refer to the label.

Freckle

Venturia carpophilum

Freckle (or scab) is a fungal disease caused by *Venturia carpophilum*. This disease affects stone fruit and is found in all growing regions, especially in warm, wet areas.

Risk period

Table 88. The peak risk period for freckle.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Freckle infection on the fruit will appear as greenish–brown to black spots arising at the stem end (Figure 164), which can combine to form a greenish, velvety blotched area if the infection is severe. Symptoms on the leaves first appear as pale, green areas, which go dark brown as the disease progresses.

Figure 164. Freckle on stone fruit.

Damage

Damage from freckle can affect fruit growth and increase the incidence of cracks in the fruit, making it unmarketable. With severe infection, leaves can fall prematurely, resulting in reduced photosynthetic ability and general tree decline.

Monitoring

Monitor weather conditions and take a preventative approach to controlling infection. Freckle is favoured by temperatures between 18 °C and 24 °C after rain.

Management

Cultural and physical

Ensure there is adequate airflow throughout the canopy to increase the rate of drying after rain. Avoid planting in low-lying areas. Remove and destroy infected fruit.

Biological

There are no biological controls for freckle.

Chemical

Spray programs for other key stone fruit diseases are likely to control freckle. However, there are fungicides registered (Table 89) to control freckle if a specific treatment is required.

Table 89. Registered or permitted products for freckle in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Chlorothalonil (Bravo Weather Stik®)	M5	7	Low	Apricots
Copper-based fungicides (various)	M1	1	Low	Check product labels for crops
Dithianon (Dinon 700 WG)	M9	21	Low	Apricots, nectarines, peaches
Mancozeb (Dithane® Rainshield® NeoTec®)	M3	14	Medium	Stone fruit
Penthiopyrad (Fontelis®)	7	Not required when used as directed	Low	Stone fruit
Sulfur (S) as polysulfide sulfur (Grochem® Lime Sulphur)	M2	Not required when used as directed	Medium	Pears, apricots, nectarines, peaches, plums, prunes; stone fruit dormant to budswell spray only
Thiram (Thiragranz®)	M3	7	Low	Stone fruit
Ziram (Ziram WG)	M3	7	Medium	Stone fruit except apricots

[1] WHP = withholding period. [2] 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 90. The peak risk period for peach leaf curl.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Leaf curl is often seen in 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 165).

Figure 165. Peach leaf curl in young leaves.

Damage

Peach leaf curl is favoured by a cool, wet spring around budswell 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 the death of the shoot. Infected fruit will have raised, irregularly-shaped and rough areas on the skin surface (Figure 166).

Figure 166. Leaf curl symptoms on a peach.

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 91.

Table 91. Registered or permitted products for peach leaf curl in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Chlorothalonil (Bravo Weather Stik®)	M5	7	Low	Peaches
Copper-based fungicides (various)	M1	1	Low	Nectarines, peaches
Copper hydroxide + mancozeb (ManKocide®)	M1 + M3	14	Medium	Stone fruit
Dithianon (Dinon 700 WG)	M9	21	Low	Nectarines, peaches
Dodine (Syllit®)	U12	Do not apply after petal fall	Low	Nectarines, peaches
Sulfur (S) as polysulfide sulfur (Grochem® Lime Sulphur)	M2	Not required when used as directed	Medium	Stone fruit except cherries (dormant to budswell spray only)
Ziram (Ziram WG)	M3	7	Low	Cherries, nectarines, peaches

[1] WHP = withholding period. [2] Always refer to the label.

Phytophthora root and collar rot

Phytophthora species

Root and collar rots caused by *Phytophthora* species, soil pathogens affecting stone and pome fruits, can cause significant tree decline and losses. Periods of high rainfall and wet soils create the highest risk for *Phytophthora*.

Risk period

Table 92. The peak risk period for phytophthora root and collar rots.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Although there are several species of *Phytophthora* that can cause root and collar rot in temperate fruit orchards, the symptoms are generally the same across the crops. 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 167). This can occur in individual trees or groups typically 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 168).

Figure 167. Phytophthora collar rot on an apple tree, showing various stages of decline from a light yellowing to premature leaf drop.

Figure 168. 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 water-logged soils. Spores move through the soil in water, hence the 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, including 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 93.

Table 93. Registered or permitted products for Phytophthora root and collar rot in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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 (PER85273, expires 31.1.28)	33	Not required when used as directed	Low	Apricots, nectarines, peaches, plums

[1] WHP = withholding period. [2] 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. It has been reported in pears and quince, however, this damage is rarely seen.

Risk period

Table 94. The peak risk period for powdery mildew.

Budswell/ 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 169). As the disease advances, the patches become a powdery white and will cover both sides of the leaf. Leaves infected with mildew will have crinkled and cupped edges (Figure 170), giving them a narrow appearance.

Figure 169. Early signs of powdery mildew infection on an apple leaf.

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 in favourable conditions. 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 170. 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 mildew is problematic.

Biological

There is currently no biological control available for powdery mildew in apples.

Chemical

The chemical options for controlling powdery mildew are listed in Table 95.

Table 95. Registered or permitted products for powdery mildew in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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 (Hostile 50SC)	C	7	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
Penconazole (Topas®)	3	14	Low	Apples
Penthiopyrad (Fontelis®)	7	28	Low	Pome fruit
Polyoxin D zinc salt (Intervene® WG Fungicide)	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

[1] WHP = withholding period. [2] Always refer to the label.

Rust

Tranzschelia discolor

Rust is caused by a fungus (*Tranzschelia discolour*) and is identified by brown rust spores on the undersides of leaves. It can be a serious disease in stone fruits.

Risk period

Table 96. The peak risk period for rust.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Rust symptoms can appear on the leaves, shoots and fruits. The upper surface of the leaf will become speckled with small yellow patches, while the underside develops rusty brown spots (Figure 171). 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.

Figure 171. Rust on a plum leaf.

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 periods of rain and heavy dews. 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 172) and treating orchards in periods that favour disease development is crucial for reducing rust in trees.

Figure 172. Monitoring weather in a prune 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

There are no known biological control agents for the rust pathogen.

Chemical

The chemical options for controlling rust are listed in Table 97.

Table 97. Registered or permitted products for rust in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Chlorothalonil (Bravo Weather Stik®)	M5	Apricots, cherries, peaches 7 Plums 1	Low	Apricots, cherries, peaches, plums
Copper oxychloride (Coppox®)	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

[1] WHP = withholding period. [2] 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.

Risk period

Table 98. The peak risk period for shot hole.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

Shot hole is initially identified by small brown spots with reddish rims on leaves. These spots grow and the centre falls out, leaving a round shot hole in the leaf (Figure 173). On the fruit, the spots (Figure 174) can develop into deep indentations.

Figure 173. Shot hole infection in apricot leaves.

Figure 174. Shot hole infection on a peach. Photo: William Brown Jr, Bugwood.org.

Damage

Shot hole reduces the tree's photosynthetic capacity. 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 budswell 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 99.

Table 99. Registered or permitted products for shot hole in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
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	Canning peaches 1 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 budswell spray only)
Thiram (Thiragranz®)	M3	7	Low	Stone fruit
Ziram (Ziram WG)	M3	7	Low	Cherries, nectarines, peaches

[1] WHP = withholding period. [2] Always refer to the label.

Silver leaf

Chondrostereum purpureum

Silver leaf occurs mainly on apples and stone fruit in all growing regions but is particularly common in areas that have damp, humid conditions.

Risk period

Table 100. The peak risk period for silver leaf.

Budswell/ green tip	Bloom	Mid season	Harvest	Postharvest	Dormancy

Disease identification

The foliage of infected trees will develop a silvery sheen (Figure 175) that is caused by light shining through leaf cells that are damaged by toxins produced by the fungus.

Figure 175. The silver sheen on an apple leaf affected by silver leaf.

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.

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 101.

Table 101. Registered or permitted products for silver leaf in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Cyproconazole + iodocarb (Garrison®)	3 + 28	Do not use on trees during the growing season	Low	Apples, apricots, peaches, plums
Tebuconazole (Greenseal®)	3	Not required when used as directed	Low	Apples, cherries

[1] WHP = withholding period. [2] 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 102. The peak risk period for sooty blotch.

Budswell/ 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 176). Although sooty blotch can appear separately, it is commonly found with fly speck (page 113).

Damage

The disease results in unsightly 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

Sooty blotch is favoured by cool, wet conditions and dense, slow-drying canopies. Monitor by inspecting fruit for blotches through mid to late summer.

Figure 176. Sooty blotch on unsprayed Cripps Pink (Pink Lady®) 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 103.

Table 103. Registered or permitted products for sooty blotch in NSW.

Active constituent (example trade name)	Fungicide group(s)	WHP[1] (days)	Effect on beneficials	Registered for use in...[2]
Copper hydroxide + mancozeb (ManKocide®)	M1 + M3	14	Medium	Apples, pears
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

[1] WHP = withholding period. [2] Always refer to the label.

Non-bearing trees

Young trees (Figure 177) that are not bearing fruit do not need the same intensive spray schedule as bearing trees.

Figure 177. Young, non-bearing orchards require monitoring for pests and diseases affecting tree health.

Problems most likely to be encountered with young apples and pears, stone fruit and persimmon are listed in Table 104 to Table 106. However, prevention is the cheapest route to healthy trees. Always source new trees from reputable nurseries and choose varieties with known pest and disease resistance. Avoid stress in young trees by supplying appropriate levels of nutrition and irrigation, and preventing competition from weeds. 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 104. Problems most likely to be encountered with young apple and pear trees.

Pest or disease	Damage	Control
Apple scab	Can severely setback 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. 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.

Table 105. 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 budswell. 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 infection of the crown root.	Treating seeds, rootstock seedlings and bare-rooted trees before planting with a biocontrol agent is advised. See Protecting 'beneficials' on page 96.
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 budswell. 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 budswell.
Summer trunk canker	This is a potentially serious disease affecting stone fruit on peach rootstock in wet soils. 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 106. Problems most likely to be encountered with young persimmon trees.

Pest or disease	Damage	Control
Ants/scale/ mealybugs	Before they become productive, young trees can be infested by scale and/or mealybug. Ants can protect and encourage these pests, leading to problems when trees start bearing fruit.	Monitor young trees closely for ants, mealybug and scale 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.

Managing postharvest diseases and disorders

John Golding and Kevin Dodds, NSW DPI

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 178) and, less often, other *Penicillium* species.

Grey mould, caused by *Botrytis cinerea* is the most frequently encountered disease in untreated fruit stored in bins. As *B. cinerea* frequently spreads from fruit to fruit, losses from an initial infection can be large.

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 178. 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 general orchard hygiene throughout the growing season. This ensures the fruit is as clean as possible when harvested, thus minimising postharvest decay during storage. Control of diseases associated with postharvest decay in the field is provided in the diseases section of this guide (page 98), with specific information given for bitter rot (page 107), brown rot (page 108) and *Alternaria* species (page 98).

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.

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 fruit bruising. Fruit injury sites are ideal entry points to 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 179) is essential for minimising potential fruit losses. Table 107 lists chemicals with registration for use as postharvest dips or drenches in NSW for pome and stone fruits and the target diseases for these crops.

Figure 179. 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 180).

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 to use for sanitising packing shed fruit dipping water transport and/or fruit washing systems are listed in Table 108. Always consult your chemical supplier and the product label for details of registered or approved uses and applications in fruit processing.

Figure 180. Sanitising water transport systems is essential to prevent the build-up and spread of fungal and bacterial infections.

Table 107. 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 (Fludy®)	12	Pome fruit: blue mould, grey mould Stone fruit: brown rot, grey mould, rhizopus rot
Imazalil (Imazacure 500 EC)	3	Apples and pears: blue mould
Iprodione (Rovral Aquaflo®)	2	Apples and pears: storage rots caused by *Botrytis* spp., *Gloeosporium* spp. and *Penicillium* spp. Stone fruits: brown rot, transit rot (suppression)
Pyrimethanil (EcoFOG-160 PYR)	9	Apples and pears moulds caused by *Penicillium* spp., *Botrytis* spp. and *Neofabrea* spp.
Thiabendazole (Storite®)	1	Apples and pears: blue mould, grey mould, fruit rot (*Gloeosporium album*)
Triforine (Saprol®)	3	Apricots, nectarines, peaches, plums, prunes: brown rot

Table 108. Common chemicals used for sanitising harvested fruit, equipment and processing water in fruit processing facilities. Note, these are approved for use in postharvest fruits.

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 (Zydox®)	Bacterial growth in flumes and 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 181) during long-term cold storage. These areas become sunken and turn darker brown as the disorder develops. Although the damage is only superficial (Figure 182), 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 181. Superficial scald symptoms on a Granny Smith apple.

Figure 182. The peel removed from a scalded and non-scalded region of a Granny Smith.

Scald incidence

Several inter-related varietal, 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 109) is probably the overriding factor in scald development.

Scald severity

Factors affecting scald severity, include:

- storage atmosphere composition and ventilation
- storage temperature and duration.

Scald control

Scald can be controlled by postharvest chemical treatments such as:

1. diphenylamine (DPA)
2. 1-methylcyclopropane (1-MCP)
3. dynamically controlled atmospheres (DCA).

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) 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 organic vapour filter) for this application method.

All product label 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-methylcyclopropane (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 and therefore 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 in maintaining quality fruit.

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.

Table 109. 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	–

Chemical thinners for pome and stone fruits

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, thus 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; 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 removing the crop by hand but has a positive effect on 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 has been observed to 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 has no effect on beneficials. The thinning effect is dependent on radiation; it will be stronger in reduced light (cloudy 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 110), however, despite these limitations, a chemical thinning program produces markedly superior results to hand-thinning, both economically and in terms of 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 chemical is important, as some cultivars do not respond well to some chemicals.

Table 110. 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. Peach and plum 80–100% bloom.	• Can cause russet. • Timing critical.
Benzyladenine (BA) (Maxcel™)	Post-bloom	Fuji, Gala, Golden Delicious, Pink Lady, Red Delicious, Sundowner	Fuji and Gala 15–22 dAFB*. Red Delicious 10–20 dAFB. Golden Delicious 10–20 dAFB.	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.	• Requires warm, dry conditions. • Toxic to bees, beneficial invertebrates and mammals. • Can cause russet and reduce seed number. • Banned from some export markets.
Ethephon* (Gro-Phon 720)	Blossom	Apples	Balloon blossom to 7 dAFB.	• Tendency to flatten fruit. • Higher rates can depress fruit size. • Not effective at cooler temperatures.
Gibberellic acid (GA) (RaLex®)	Inhibits next season blossom	Apricots, nectarines, peaches	Flower bud initiation stage.	• Applied previous season. • Might delay harvest.
Metamitron (Brevis®)	Post-bloom	Apples, pears	8–16 mm fruitlet diameter.	• Can cause minor leaf phytotoxicity. • Thinning effect dependent on radiation.
Naphthalene acetic acid (NAA) (NAA20)	Blossom	Apples, pears	Full bloom to 5 dAFB. 2 sequential sprays might be required, the first applied at full bloom and the second 3–5 dAFB.	• Can depress fruit size, cause russet and reduce seed number. • Pygmy fruit if applied later than 10 dAFB. • Interacts with cytolin. • Rewetting causes over-thinning.

*Ethephon is not registered in NSW for fruit thinning but can be used for complete fruit removal.
dAFB = days after full bloom.

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 111) 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 112) 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 113) can help break dormancy and/or compress flowering to encourage more even bloom, pollination and fruit-set.

Table 111. 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 following season	Apples
Gibberellins A4 and A7 + 6-benzyladenine (Grochem BaGA®)	Stimulation of lateral growth	Apples, cherries
Paclobutrazol (Payback®)	Reduce vegetative growth	Apples (red delicious, granny smith), apricots, cherries, nectarines, peaches, plums
Prohexadione-calcium (Regalis-Plus®)	Shoot growth reduction	Apples, cherries

Table 112. Harvest management and fruit quality products registered in NSW.

Active constituent (example trade name)		Purpose	Registered for use in…
1-methylcyclopropene (1-MCP)	(Harvista®)	Decrease fruit maturation rate	Apples preharvest
	(SmartFresh™)	Improved postharvest quality	Apples, apricots, nectarines, pears, plums, persimmons
6-benzyladenine + gibberellins A4 and A7 (Cytolin®)		Improve fruit typiness (elongation)	Apples (Red Delicious)
Aminoethoxyvinylglycine (AVG) (Retain®)		Delay fruit maturity, increase fruit firmness, size and storage potential	Apples, stone fruit except cherries

Table 112. Harvest management and fruit quality products registered in NSW, page 2

Active constituent (example trade name)	Purpose	Registered for use in…
Ethephon (Promote®)	Apples (certain varieties) advancement of maturity, enhance fruit colour	Apples (varieties – see label)
	Cherries (certain varieties) promotes evenness of maturity and early colour development	Cherries (varieties – see label)
Gibberellic acid (GA) (ProGibb®)	Delay harvest maturity	Cherries, prunes
Naphthalene acetic acid (NAA) (NAA Stop Drop®)	Assist prevention of preharvest fruit drop	Apples, pears

Table 113. 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®)	Dormancy regulator	Apples, plums, prunes
Decanol alkoxylate (Erger®)	Dormancy breaker	Fertiliser adjuvant with label recommendations for apples and cherries
Fatty acid esters-canola (Waiken®)	Advance or set-back budbreak	Apples, cherries

Managing weeds

Why manage weeds?

Rapid canopy establishment and early cropping are keys to profitability in any orchard block, particularly modern, capital-intensive systems. Weeds compete with trees for moisture and nutrients and can also create a favourable microclimate for pests and diseases.

Competition from weeds in young, developing orchards can delay canopy establishment and productivity. Having an effective weed management strategy will help with orchard establishment, early yields and hygiene.

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 across blocks. Be aware of new weeds appearing, have them identified if necessary, and work towards eradicating them and reducing their 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 periodically cleaning orchard equipment.

Management strategies and control options

The most appropriate weed management strategy will vary from site to site and will depend on factors including 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). Strategies need to respond to changing weed spectra and growing conditions. Weed management methods can be grouped as either physical or chemical, and can incorporate elements of both.

Physical weed control

Cultivation

Cultivation was once a common commercial practice in orchards and it does reduce competition from weeds, but at some cost. Disturbing the topsoil is now known to negatively affect soil structure and organic matter levels. Cultivation also increases erosion risk and can result in some root damage to trees, especially in blocks on dwarf rootstocks. Spot cultivation using a hoe is labour-intensive, but might be an option for smaller orchards as an alternative to broad-scale cultivation or spot spraying.

Thermal weeding

Research shows that flame or thermal weeding using propane burners, hot air or hot water can be effective on small seedlings, but is less effective against larger annual or perennial weeds. There are health and safety and fire risks associated with these methods. Do not use thermal weeding near trees less than 3 years old, as crops can be severely damaged.

Grazing animals

Grazing sheep, geese and fowls can suppress weed growth and reduce seed load in the orchard. Geese are heavy feeders of weeds such as grasses and they also help to clean up windfall fruit. Sheep can cause damage to trees if other feed is scarce.

If orchard-grazing animals are intended for sale, be aware of chemical residue issues. Consult chemical labels for information on stock withholding periods.

Mulching

If done correctly, mulching represents the most effective alternative to chemical weed control. Mulching the under-tree row with large quantities of organic materials such as straw, old hay or bark chips has multiple benefits including:

- moisture retention
- soil temperature regulation
- organic matter and soil microbe build-up
- weed control.

To be effective as weed control, mulch must be applied at sufficient thickness to act as a physical barrier to sunlight and weed growth. This depth will depend on the type of mulch being applied.

Side-cast mowers deposit slashings along the tree row. This can help suppress weeds and build up organic matter, but will not be effective as a stand-alone mulch treatment if the aim is to achieve a weed-free strip.

Growers should also be aware of the possibility of nitrogen tie-up effects when using some raw, non-composted mulches.

Chemical weed control

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 114) 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 without using a post-emergent herbicide.
2. **Post-emergent selective grass herbicides** (Table 115) 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 116) 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 142.

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.

Should I be concerned about resistance?

Yes. Ryegrass resistance to glyphosate is present in orchards and vineyards in Australia because of an over-reliance on Group 9 herbicides e.g. glyphosate.

Herbicides work by interfering with specific processes in plants, known as the mode of action (MoA). All herbicides have been classified into groups according to their MoA.

Herbicide MoA classifications have been updated internationally to capture new active constituents and ensure the MoA classification system is globally relevant.

The global MoA classification system is based on numerical codes that provide infinite capacity to accommodate new herbicide MoA becoming available, unlike the alphabetical codes currently used in Australia. We have updated our MoA tables to include both the new number and old letter (shown in brackets).

Some groups are more likely to develop resistance and are considered high risk. Refer to product labels or Table 114 to Table 116 to determine the MoA group.

To minimise the risk of herbicide resistance developing in the orchard:

- Know the herbicide groups.
- Do not rely on chemicals from the same group for every spray.
- Use a lower risk herbicide in preference to a high risk one; herbicides are ranked for their risk of developing resistance, with groups 1 and 2 considered highest risk.

- Look for surviving weeds after spraying and prevent these from setting seed.
- Use as many weed control techniques as practical and do not rely solely on herbicides.

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% of 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 used to be 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 141.
- 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 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).

Simple and easy calibration

The most common procedure for calibrating herbicide spray equipment is:

1. Select the tractor engine 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 over 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 exactly 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** × **W** × **T** ÷ **V**

In our example, the area covered is

100 m × 1.5 m × 500 L ÷ 10 L = 7,500 m^2 or 0.75 ha (there are 10,000 m^2 per hectare)

Herbicide required in a full tank:

= application rate [R] × area covered by a full tank

In our example the amount of herbicide required = 3.75 kg/ha × 0.75 ha = 2.8 kg

Herbicides and their uses

Table 114. Pre-emergent residual herbicides. *The number in the herbicide column represents the new MoA and the previous letter is shown in brackets.

Active ingredient (example trade name)	Herbicide group*	Crop	Weeds controlled	Remarks
Flumioxazin (Chateau®)	14 (G)	Pome and stone fruit	Active against a wide range of grass and broadleaf weeds.	Requires at least 15 mm of rain or irrigation to activate. Applied postharvest to budbreak, add a knockdown for weeds taller than 100 mm.
Isoxaben (Gallery® 750)	29 (O)	Orchards	Certain broadleaf weeds.	Requires incorporation by at least 12.5 mm rainfall or sprinkler irrigation within 21 days of application.
Napropamide (Devrinol-C 500 WG)	0 (K)	Stone fruit	Annual grasses and some broadleaf weeds.	Incorporate to a depth of 20–50 mm.
Norflurazon (Zoliar® 800 DF)	12 (F)	Apples, pears, stone fruit	Active against a wide range of annual broadleaf weeds and grasses.	Do not use more than 4.2 kg product/ha in any one season. Do not apply to trees younger than 18 months.
Oryzalin (Cameo™ 500)	3 (D)	Apples, pears and stone fruit	Active against a wide range of annual broadleaf weeds and grasses.	Use lower rate for short term (up to 4 months) and higher rate for longer-term (6–8 months) control. Activated by moisture.
Oxyfluorfen (Goal®)	14 (G)	Apples, pears, apricots, plums and peaches	Active against 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 budswell. For post-emergent spike, use at 75 mL/ha with a glyophosate product or 250 mL/ha with a paraquat or diquat/paraquat product. Do not use on apples or pears younger than 3 years old.
Pendimethalin (Stomp 440®)	3 (D)	Deciduous fruits	Active against a wide range of annual broadleaf weeds and grasses.	Requires moisture for incorporation.
Simazine (various)	5 (C)	Apples, pears	Active against a range of broadleaf weeds.	Do not use on trees younger than 2 years old. Use higher rate for medium to heavy textured soils.
Terbacil (Sinbar®)	5 (C)	Apples, peaches	Annual weeds and perennial grasses.	Do not apply to trees younger than 3 years old. Do not apply on sandy or gravelly soils. Sorrel can become predominant after repeated applications of terbacil.

Table 115. Post-emergent selective grass herbicides.

Active ingredient (example trade name)	Herbicide group	Crop	Weeds controlled	Remarks
Clethodim (Status®)	1 (A)	Non-bearing fruit trees	Annual grasses	Apply to 2-leaf to fully tillered grasses.
Fluazifop-p-butyl (Fusilade® Forte)	1 (A)	Apples, pears, stone fruit	Only controls annual and perennial grasses	Withholding period not required on these crops when used as directed.
Haloxyfop (Verdict®)	1 (A)	Apples, pears, stone fruit, persimmons	Annual and perennial grasses	Apply to small, actively growing grasses.

Table 116. Post-emergent non-selective knockdown herbicides.

Active ingredient (example trade name)	Herbicide group	Crop	Weeds controlled	Remarks
Amitrole + ammonium thiocyanate (Amitrole T)	34 (Q)	Orchards	Broad-spectrum. Active against broadleaf weeds (including marshmallow) and sedges.	Trees should be at least 3 years old. Do not apply within 56 days from harvest. Wet weeds thoroughly. Use higher rate for marshmallow.
Amitrole + paraquat (Guerrilla®)	22 (L) + 34 (Q)	Orchards	Various.	Spray young weeds in late winter for spring–summer. Use higher rate in spring.
Asulam (Rattler® 400)	18 (R)	Apples	Dock.	Apply to actively growing docks in spring when leaves are fully expanded but before flower shoots emerge.
Carfentrazone-ethyl (Spotlight Plus®)	14 (G)	Young or established orchards	Small-flowered mallow and certain other annual broadleaf weeds.	Tank mix with a knockdown herbicide to assist with weed control.
Diquat (Reglone®)	22 (L)	Orchards	Capeweed.	Avoid spray drift onto plant parts with green pigments. Spray only actively growing weeds (50–100 mm high). Wet thoroughly (add wetter).
Glufosinate ammonium (Basta®)	10 (N)	Pome and stone fruit orchards	Broad-spectrum herbicide that controls a wide range of grass and broadleaf weeds including willow herb.	Do not use around trees less 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.
Glyphosate (Roundup®)	9 (M)	Apples, pears and stone fruit	Controls 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 (M) + 14 (G)	Pome and stone fruit orchards	Broadleaf weeds including marshmallow.	Do not allow spray or drift to contact green bark, stems, foliage or fruit.
Paraquat (Gramoxone®)	22 (L)	Orchards	Most annual grasses and some broadleaf weeds. Add diquat to control capeweed.	Avoid spray drift onto plant parts with green pigment. Spray only actively growing weeds (50–100 mm high). Wet thoroughly.
Paraquat + diquat (Spray. Seed®)	22 (L)	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 (G)	Pome fruit orchards	Controls 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, Biosecurity and Food Safety, NSW DPI

A pest or disease is resistant to a specific chemical when that chemical no longer provides the control it did previously. Repeatedly spraying pests and diseases with a particular chemical causes resistance because all populations contain very small numbers of individuals that are resistant to a given pesticide and, while continuing to use the pesticide will kill susceptible individuals, it will also select a strain that is increasingly composed of resistant forms. Once the resistant population reaches a critical proportion, the chemical will not be effective.

Managing resistance

Managing resistance for all pesticides is an important consideration when choosing a control strategy. One strategy is rotating chemical groups so the target is not being repeatedly treated with the same type of chemical. In the past, it has often been difficult to distinguish between chemical groups and their different modes of action; a factor important in successful rotation. Now all registered pesticides have a symbol on the label that identifies the action group to which they belong. This helps growers to choose a product from a different chemical action group when seeking to rotate chemicals in a program. An identification scheme was set up for herbicides (see page 142), fungicides (Table 117) and insecticides and miticides (Table 118).

Product labels incorporate a resistance warning and many include crop-specific instructions relating to the number of applications permitted for use in that crop. Agricultural chemical users must always read the label and any permit before using the product and strictly follow the conditions as directed. Complying with resistance management instructions will help to minimise resistance.

Table 117. Fungicide groups[1,2].

Group	Chemical class	Common name	Example trade name*
1	Benzimidazole	Thiabendazole	Tecto Flowable®
2	Dicarboximide	Iprodione	Rovral®
		Procymidone	Sumisclex® 500
3	Imidazole	Imazalil	Fungaflor®
	Piperazine	Triforine	Saprol®
	Triazole	Difenoconazole	Bogard®
		Hexaconazole	AW Hostile 50SC
		Mefentrifluconazole	Belanty®
		Myclobutanil	Systhane®
		Penconazole	Topas®
		Propiconazole	Tilt® 500 EC
7	Pyrazole carboxamide	Fluxapyroxad	Sercadis®
		Penthiopyrad	Fontelis®
		Isopyrazam	Seguris® Flexi
	Pyridine carboxamides	Boscalid	Pristine®
	Pyridinyl-ethyl-benzamides	Fluopyram	Luna® Sensation
8	Hydroxypyrimidine	Bupirimate	Nimrod®
9	Anilinopyrimidine	Cyprodinil	Chorus®

Table 117. Fungicide groups[1,2], page 2

Group	Chemical class	Common name	Example trade name*
11	Strobilurin	Kresoxim-methyl	Stroby®
		Trifloxystrobin	Flint®
		Mandestrobin	Intuity™
12	Phenylpyrrole	Fludioxonil	Scholar®
19	Polyoxins	Polyoxin-D zinc salt	Intervene®
33	Ethyl phosphonate	Fosetyl	Aliette®
M1	Inorganic	Copper fungicides	Kocide®
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	Thiragranz®
		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 118. Insecticide and miticide groups[1,2].

Group	Chemical class	Common name	Example trade name*
1A	Carbamate	Carbaryl	Bugmaster®
		Methomyl	Lannate®
		Pirimicarb	Aphidex®
1B	Organophosphate	Chlorpyrifos	Strike-Out®
		Diazinon	Diazol®
		Maldison	Fyfanon®
		Omethoate	Folimat®
		Prothiofos	Tokuthion®
		Trichlorfon	Lepidex®
2B	Phenylpyrazoles (fiproles)	Fipronil	Amulet Cue-Lure®
3	Pyrethroid	Alpha-cypermethrin	Alpha-Scud®
		Bifenthrin	Talstar®
		Tau-fluvalinate	Mavrik® Aquaflow
3A	Pyrethroid-ester	Etofenprox	Trebon®

Table 118. Insecticide and miticide groups[1,2], page 2.

Group	Chemical class	Common name	Example trade name*
4A	Neonicotinoid	Acetamiprid	Cormoran® (a component of)
		Clothianidin	Samurai®
		Imidacloprid	Confidor® 200 SC
		Thiacloprid	Calypso®
4C	Sulfoximine	Sulfoxaflor	Transform®
5	Spinosyn	Spinetoram	Delegate®
		Spinosad	Eco-naturalure®
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	*Bacillus thuringiensis* subsp. *Kurstaki*	DiPel®
12A	Organotin	Fenbutatin oxide	Torque®
12C	Organosulfur miticide	Propargite	Betamite®
13A	Chlorfenapyr	Chlorfenapyr	Secure®
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®
25	Beta-ketonitrile derivatives	Cyflumetofen	Danisaraba®
28	Diamide	Chlorantraniliprole	Altacor® Hort
		Cyclaniliprole	Teppan® 50 SL
		Tetraniliprole	Vayego® 200 SC
29	Pyridincarboxamide	Flonicamid	Mainman®

[1]Trade names that include the common chemical name are not listed.

Source: CropLife Australia (https://www.croplife.org.au/).

[2]The information in the table shows fungicide groups based on mode of action only. For a chemical's compatibility with IPM, please see the individual crop tables and the label.

*Example only.

Your responsibilities when applying pesticides

Farm Chemicals Unit, Biosecurity and Food Safety, NSW DPI

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).

Any individual or organisation can apply for a permit. The APVMA can be contacted on 02 6770 2300 or by email (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. See 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 in foods for human and animal consumption.

Some export markets have a lower residue tolerance than 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 may be unduly exposed. Drift may 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 (www.epa.nsw.gov.au/pesticides/aerialapplicators.htm).

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 risk 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 application
- records must be made in English and kept for 3 years.

Globally Harmonised System of classifying and labelling of chemicals

The Globally Harmonised System (GHS) is an international system for classifying hazards and communication 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) 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 for different industries and situations to provide guidance for industries.

Work Health and Safety Act 2011 (NSW)

SafeWork NSW administers the *Work Health and Safety Act 2011* (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).

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 accumulation of flammable and combustible materials
- provision of fire protection, firefighting 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.

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Analytical laboratories

Below is a list of commercial laboratories that undertake analysis of food commodities and other materials for chemical residues:

Eurofins Agroscience Testing
Phone 02 9900 8442
Website https://www.eurofins.com.au/locations/eurofins-agroscience-testing-lane-cove/

National Measurement Institute
Phone 1800 020 076
Email info@measurement.gov.au

National Association of Testing Authorities
Phone 02 9736 8222
Website https://www.nata.com.au

Information sources

APVMA (www.apvma.gov.au)

Australian Code for the Transport of Dangerous Goods by Road and Rail (www.ntc.gov.au/heavy-vehicles/safety/australian-dangerous-goods-code/)

Bureau of Meteorology (www.bom.gov.au)

Environment Protection Authority (www.epa.nsw.gov.au/)

Hazardous Substances Information System (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)

National Association of Testing Authorities (www.nata.com.au/)

NSW DPI resources on QFF (www.dpi.nsw.gov.au/biosecurity/insect-pests/qff)

Safe use and storage of chemicals in agriculture (https://www.safework.nsw.gov.au/advice-and-resources)

Work Health and Safety Act 2011 (www.legislation.gov.au/Details/C2017C00305)

Work Health and Safety Regulation 2011 (www.legislation.gov.au/Details/F2011L02664)

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 ÷ 100.

Examples

Spraying thinners

How much carbaryl product (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)

$$= \frac{\text{1,000 ppm or mg/L}}{\text{500 g/L} \times 10}$$

= 0.2 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)

$$= \frac{\text{2,000 ppm or mg/L}}{\text{310 g/L} \times 10} \times \frac{\text{1,100 L}}{100}$$

= 7 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)

$$= \frac{\text{75 mL} \times \text{1,500 L}}{\text{100 L}}$$

= 1,125 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 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 ÷ 500 or 4×.

The spray unit set up for concentrate spraying now covers 4 times the area that it did when set up for dilute spraying.

Additional information on concentrate spraying might be available on the label.

Climate vulnerability assessment of primary industries

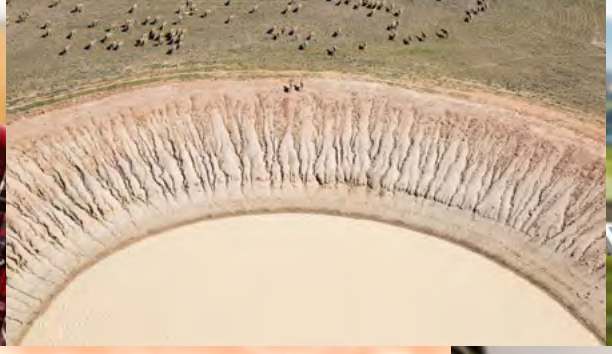
Improving our understanding of climate change risks and effects on NSW primary industries

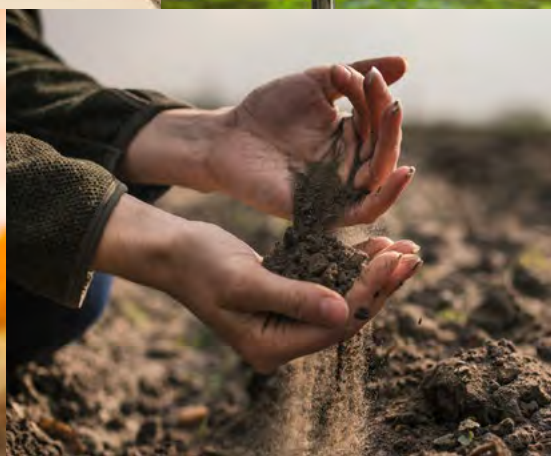
NSW DPI, through the Climate Change Research Strategy, has undertaken a comprehensive assessment of the vulnerability of key commodities to climate change in NSW. The assessment will fill gaps in our knowledge about the effects of climate change on the state's primary industries.

For horticulture and viticulture, the vulnerability assessment project has analysed climate change effects for citrus (Navel orange), cherry (Lapin), almond (Non-pareil), walnut (Chandler), blueberry (southern highbush), macadamia and wine grapes (Chardonnay). In addition, the project is also currently integrating climate change effects on related pests and diseases, such as Queensland fruit fly.

This work will help provide a clearer picture of potential climate change effects on the horticulture and viticulture sectors in NSW, looking ahead to 2050. This work will help identify adaptation needs and priorities that can guide future research and development activities to increase the resilience of this critical sector to a changing climate.

We are close to finalising the vulnerability assessment for cherry, and the results will be released later this year. To access the report, please go to the NSW DPI website (https://www.dpi.nsw.gov.au/dpi/climate/climate-change-and-primary-industries) or email (vulnerability.assessment@dpi.nsw.gov.au). We welcome the opportunity to share the findings with you and discuss the next phase of work to support your industry in adapting to climate changes in NSW.

Seasonal Conditions Monitoring Program

State Seasonal Update: Conditions and Outlook

The **State Seasonal Update** is produced monthly and is the official point of reference of seasonal conditions across NSW for producers, government, stakeholders and the public.

Combined Drought Indicator: Latest NSW Drought Maps

Is an interactive tool that provides a snapshot of current seasonal conditions for NSW, factoring in rainfall, soil moisture and pasture/crop growth indices.

Seasonal Conditions Information Portal

Uses technology that allows fast, stable transfer of data and information direct from the EDIS system to your computer. The portal contains several downloadable features from the **NSW Combined Drought Indicator.**

Farm Tracker Mobile Application

Farm Tracker is a tool you can use to record seasonal conditions. You can:

1. Complete a simple crop, pasture or animal survey
2. Keep and manage a photo diary of your farm
3. Monitor the same paddock over many years

Have your say

Complete this survey and tell us what is important to you as DPI continues to improve our Seasonal Conditions monitoring program. Eg. improved local accuracy of data and climate networks, better ways of communicating, or strengthening linkages to drought management and relief measures.

Department of Primary Industries
www.dpi.nsw.gov.au

NSW GOVERNMENT

Useful resources

Publications

Several publications are mentioned in this guide. Many are available from NSW DPI through the Tocal Agricultural College bookshop. Contact details are:
Phone: 1800 025 520
Email tocal.college@dpi.nsw.gov.au
Web www.tocal.nsw.edu.au/publications

Primefacts usually contain illustrations of the pest or disease being described. These are available free from the NSW DPI website (www.dpi.nsw.gov.au/agriculture/horticulture).

Integrated pest disease and weed management manual for Australian apple and pears is a practical guide for pome fruit orchardists wanting to implement IPM. This is available free from the Hort Innovation website (www.horticulture.com.au/globalassets/hort-innovation/resource-assets/2020-21-australian-apple-and-pear-ipdm-manual.pdf).

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 DPI website (www.dpi.nsw.gov.au/agriculture/horticulture/stone-fruit/pests,-diseases-and-disorders/summerfruit-ipdm).

Spray Sense is a publication providing information on pesticide issues. Topics include sprayer calibration, testing for residues, storing pesticides, disposing of empty containers, reading a label, and several others. ***Spray Sense*** can be downloaded free from the NSW DPI website (https://www.dpi.nsw.gov.au/agriculture/chemicals/spray-sense-leaflet-series).

The Good Bug Book (second edition) is a valuable reference for the beneficial organisms commercially available for biological control in Australia. It includes illustrations as well as tables of information on their susceptibility to pesticides and is published by Integrated Pest Management Pty Ltd for the Australasian Biological Control Association Inc. It can be purchased from the Bugs for Bugs website (https://bugsforbugs.com.au/product/good-bug-book-cd/).

Internet sites

Pesticides – use and disposal

Australian Pesticides and Veterinary Medicines Authority (www.apvma.gov.au)

ChemClear (www.chemclear.com.au)

drumMuster (www.drummuster.org.au)

InfoPest (www.infopest.com.au)

Agricultural industry organisations

Apple and Pear Australia Ltd (www.apal.org.au)

Cherry Growers Australia (www.cherrygrowers.org.au)

Hort Innovation (www.horticulture.com.au)

National Farmers' Federation (www.nff.org.au)

NSW Farmers' Association (www.nswfarmers.org.au)

Persimmons Australia (www.persimmonsaustralia.com.au)

Summerfruit Australia Ltd (www.summerfruit.com.au)

State government

Department of Agriculture and Food, Western Australia (https://www.agric.wa.gov.au/)

Department of Agriculture, Fisheries and Forestry (www.daf.qld.gov.au)

Department of Jobs, Precincts and Regions, Victoria (https://djpr.vic.gov.au/)

Department of Natural Resources and Environment Tasmania (www.dpipwe.tas.gov.au)

Department of Primary Industries and Regions SA (https://www.pir.sa.gov.au/)

Local Land Services (www.lls.nsw.gov.au)

NSW Department of Primary Industries (www.dpi.nsw.gov.au)

NSW Environment, Energy and Science (www.environment.nsw.gov.au)

NSW Rural Assistance Authority (www.raa.nsw.gov.au)

SafeWork NSW (www.safework.nsw.gov.au)

Rural assistance

Health NSW (www.health.nsw.gov.au)

NSW Rural Assistance Authority (www.raa.nsw.gov.au)

Services Australia (https://www.servicesaustralia.gov.au/)

Federal government

ABC Rural Department (www.abc.net.au/rural)

Australian Trade Commission (www.austrade.gov.au)

Department of Agriculture, Fisheries and Forestry (www.agriculture.gov.au)

Plant Health Australia (www.planthealthaustralia.com.au)

Climate

Commonwealth Bureau of Meteorology (www.bom.gov.au)

Environment

Department of Agriculture, Water and the Environment (www.environment.gov.au)

NSW Environment, Energy and Science (www.environment.nsw.gov.au)

NSW Environment Protection Authority (www.epa.nsw.gov.au)

Alternative systems (organics)

Australian Organic (www.austorganic.com)

National Association for Sustainable Agriculture Australia (https://nasaaorganic.org.au/)

Organic Industries Australia (https://organicindustries.org.au/)

Economic information

Australian Bureau of Agricultural and Resource Economics and Sciences (www.agriculture.gov.au/abares)

Export and import support

Biosecurity Import Conditions Database (BICON) (www.agriculture.gov.au/import/online-services/bicon)

Codex – International Food Standards (www.agriculture.gov.au/ag-farm-food/food/codex)

Manual of Importing Country Requirements (MICoR) (www.agriculture.gov.au/export/micor)

Market price information

Market Information Services (www.marketinfo.com.au)

Technical production information

Agencies and universities

Commonwealth Scientific and Industrial Research Organisation (CSIRO) (www.csiro.au)

Fruit and Nut Research and Information Centre, University of California (http://fruitsandnuts.ucdavis.edu)

New Zealand Ministry for Primary Industries (www.mpi.govt.nz)

South Australia Research and Development Institute (www.pir.sa.gov.au/research)

Tasmanian Institute of Agriculture (www.utas.edu.au/tia)

Tree Fruit Research and Extension Center, Washington State University (www.tfrec.wsu.edu)

United Kingdom Department for Environment, Food and Rural Affairs (www.gov.uk/defra)

United States Department of Agriculture (USDA) (www.usda.gov)

Integrated pest management

Australasian Biological Control Association Inc (www.goodbugs.org.au)

Quality assurance

Freshcare Australia (www.freshcare.com.au)

Nurseries

Australian Nurserymen's Fruit Improvement Company (ANFIC) (www.anfic.com.au)

Fleming's Nurseries (https://www.flemings.com.au/nurseries/)

Levity CROP SCIENCE

Lono

Environmentaly Stable Amine Nitrogen

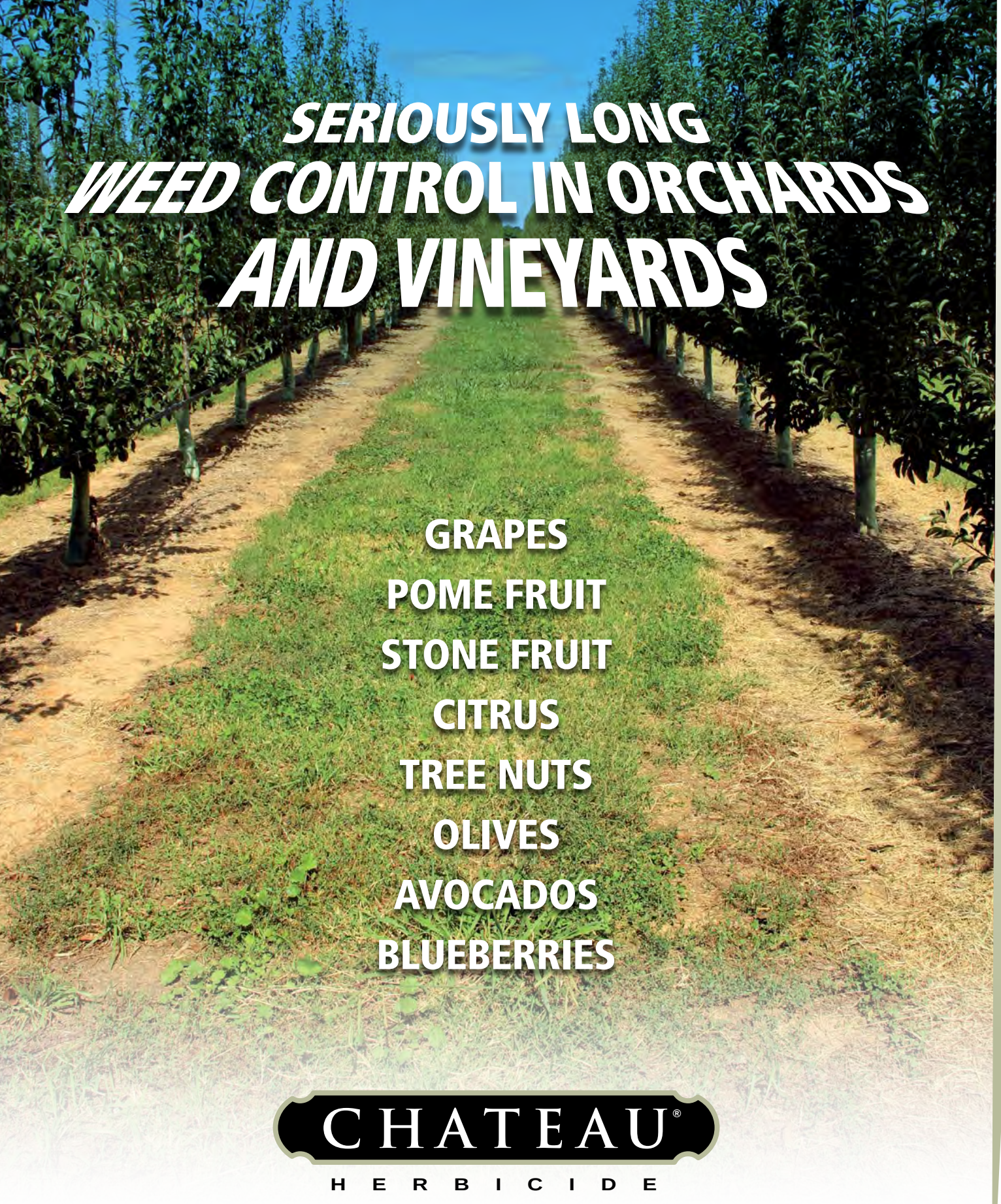
Lono is a smart fertiliser that focuses the plant on reproductive growth (flowers, fruit and roots) encouraging reproductive growth, rather than the vegetative growth stimulated by conventional N fertilisers. Lono uses Levity's LimiN chemistry to hold nitrogen in the amine form which improves photosynthesis, root growth and yield.

AU Distributor

PRODOZ

Prodoz International
14 Mary crt, Epping,
VIC 3067, Australia
0467 628 493
zen@prodoz.com.au

www.levitycropscience.com.au



SUMITOMO CHEMICAL
AgroSolutions Division

Scan here to see more information about Chateau Herbicide

www.sumitomo-chem.com.au

Need more help or information?

Talk with our Temperate Fruits Development Team

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Facebook group

Want to interact with us and other temperate fruit growers on Facebook? Why not join our closed group NSW DPI Temperate Fruits (https://www.facebook.com/groups/2952421994827990/)

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.

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 across rural and regional New South Wales. LLS bring together agricultural production advice, biosecurity, natural resource management and emergency management into a single organisation. LLS horticulture officers help producers address the challenges they face today and take advantage of future opportunities, to achieve improvements in crop yields, orchard management and market access.

Producers can contact their nearest LLS office (https://www.lls.nsw.gov.au/) by phoning 1300 795 299.

NSW DPI 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 both within or across states. All enquiries should be directed to Plant Health Australia (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.