ECOMIX HIGH PRECISION COCO BAGS

CUSTOM MADE GROW BAGS FOR
BLUE BERRIES, BLACK BERRIES, RASPBERRIES & STRAWBERRIES
Berry plant protection guide 2019

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Always read the label
Users of agricultural chemical products must always read the label and any permit before using the product and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from any compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

Permits
Some of the chemical use patterns quoted in this publication are approved under permits issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and 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.
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About this guide

This is the third edition of the *Berry plant protection guide*. It is the latest in a series of similar publications that have served industry for over 57 years, providing up-to-date information on all aspects of protecting your orchard from pests and diseases. This edition will have an integrated pest management (IPM) focus, providing information on a range of different methods that can be used to manage pest insects and diseases in berry crops.

**Feature articles**

*Dr Rosalie Daniel, Plant Pathologist* with NSW Department of Primary Industries at Ourimbah.

Dr Daniel discusses blueberry replant decline, an emerging serious problem worldwide. This article provides an update on the symptoms and causes of replant disease as well as some of the methods that can be used to prevent replant decline from occurring.

*Scott Herd, Northern AgriServices* Casino.

Scott discusses the importance of understanding tank mixing and compatibility. This section also includes a multiple tank mix solutions guide.

**Distribution**

The guide aims to provide commercial orchardists with up-to-date technical information on all aspects of crop protection and is available free of charge to Australian blueberry, raspberry and blackberry growers. The guide is also published on the [NSW Department of Primary Industries website](http://www.dpi.nsw.gov.au/agriculture/horticulture/berries).

**Pesticides**

We do not list every pesticide that is registered for a specific use but rather guide growers in their choice of chemicals.

It is our policy to use common chemical names or active ingredients, not trade names, when referring to pesticides, crop regulation compounds and nutrient sprays. Some users find this inconvenient because the chemical name is often in small print on product labels compared with the prominence given to the trade name. However, it is necessary because there can be many product names for the same active ingredient and it would be impossible to list them all at each mention in the guide.

Under the pesticides registration system administered by the Australian Pesticides and Veterinary Medicines Authority (APVMA), individual products are registered for use in or on specific crops for specific weeds, pests or diseases. Also, there can be variations in use recommendations between states for the same crop, even differences in times of application or treatment intervals.

Using common chemical names in recommendations is intended to simplify the advice. It also means that at least one product containing that active ingredient is registered for the purpose given. Pesticide users must follow all label and permit instructions.

**Pesticide use is under constant scrutiny through residue surveys. It is imperative that these valuable tools for fruit production are not misused.**

**Acknowledgements**

We thank the officers of NSW Department of Primary Industries and other organisations who have helped to produce the guide. We would like to thank Bruce Browne Farm Chemical Officer NSW DPI for reviewing the pesticide recommendations.

Once again, agricultural chemical companies have provided information on their products and helpful suggestions and we thank them for their involvement and interest.

We welcome suggestions, comments and ideas from growers and technical people alike, which will improve the usefulness and relevance of the guide.

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Compatibility

Scott Herd, Northern AgriServices Casino

Hitting the target: the importance of understanding tank mixing and compatibility

Effectively controlling pests and diseases can be the difference between a valuable, successful crop or a mediocre, disappointing one. Successfully applying pesticides requires an understanding of the pest, the product and the efficacy of the sprayer in hitting the target.

Mixing multiple products into one tank mix can save on repeated applications or treatments, but it can also be unproductive if the products are not compatible or compromise the efficacy of the products applied. For instance, a fruit fly chemical might not work if the pH of the water has been changed by a fungicide used to protect against rust. In this case, it would be sensible to apply the products separately.

Using products strategically, rather than throwing everything into the tank and hoping it works, is much more effective. If you are a farm manager, contractor or advisor, the grower will not measure your success by the number of products applied; they want a protected crop that produces a good yield in a cost-effective and responsible way.

All product users must read product labels and be aware that the instructions on product labels can change.

Checking spray tank water
• what is the water source?
• is the pH of the water stable?
• do you check the pH regularly?
• is there adequate agitation in your spray tank?

If you are unsure about the compatibility of products (e.g. can they be mixed together and in what order should you put them in), or if a wetting agent might be required, you should read the label, ask your chemical supplier or contact the manufacturer.

A simple jar test (Table 1) can give some indication of whether products are physically compatible, but does not guarantee that you will not cause injury to the plant or that the mix will be effective against the desired targets.

Table 1. A simple jar test to check for compatibility.

<table>
<thead>
<tr>
<th></th>
<th>Final quantity</th>
<th>Option one</th>
<th>Option two</th>
<th>Option three</th>
<th>Option four</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank mix 50 L</td>
<td>8 L</td>
<td>20 L</td>
<td>500 mL</td>
<td>40 mL</td>
<td></td>
</tr>
<tr>
<td>Jar test 1 L</td>
<td>160 mL</td>
<td>400 mL</td>
<td>10 mL</td>
<td>0.8 mL</td>
<td></td>
</tr>
<tr>
<td>Tank mix 100 L</td>
<td>8 L</td>
<td>20 L</td>
<td>500 mL</td>
<td>40 mL</td>
<td></td>
</tr>
<tr>
<td>Jar test 1 L</td>
<td>80 mL</td>
<td>200 mL</td>
<td>5 mL</td>
<td>0.4 mL</td>
<td></td>
</tr>
<tr>
<td>Tank mix 200 L</td>
<td>8 L</td>
<td>20 L</td>
<td>500 mL</td>
<td>40 mL</td>
<td></td>
</tr>
<tr>
<td>Jar test 1 L</td>
<td>40 mL</td>
<td>100 mL</td>
<td>2.5 mL</td>
<td>0.2 mL</td>
<td></td>
</tr>
<tr>
<td>Tank mix 500 L</td>
<td>8 L</td>
<td>20 L</td>
<td>500 mL</td>
<td>40 mL</td>
<td></td>
</tr>
<tr>
<td>Jar test 1 L</td>
<td>16 mL</td>
<td>40 mL</td>
<td>1 mL</td>
<td>0.08 mL</td>
<td></td>
</tr>
<tr>
<td>Tank mix 1000 L</td>
<td>8 L</td>
<td>20 L</td>
<td>500 mL</td>
<td>40 mL</td>
<td></td>
</tr>
<tr>
<td>Jar test 1 L</td>
<td>8 mL</td>
<td>20 mL</td>
<td>0.5 mL</td>
<td>0.04 mL</td>
<td></td>
</tr>
</tbody>
</table>

Mixing products

A series of steps should be followed (Table 2) and remember 'dilution is the solution'; always:
• read the label
• add the product to water under agitation
• never add water to the product
• never mix products before adding to water.

Table 2. Multiple tank mix solutions guide.

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Fill the spray tank to at least 70% full. Run agitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>Add any water conditioners e.g. acidifier</td>
</tr>
<tr>
<td>Step 3</td>
<td>Add any water-dispersable granular products and allow at least 10 minutes for complete dispersion</td>
</tr>
<tr>
<td>Step 4</td>
<td>Add any suspension concentrate products</td>
</tr>
<tr>
<td>Step 5</td>
<td>Add any emulsifiable concentrate products</td>
</tr>
<tr>
<td>Step 6</td>
<td>Add any soluble liquid products</td>
</tr>
<tr>
<td>Step 7</td>
<td>Fill the spray tank to nearly full</td>
</tr>
<tr>
<td>Step 8</td>
<td>Add any adjuvants</td>
</tr>
<tr>
<td>Step 9</td>
<td>Fill the tank</td>
</tr>
</tbody>
</table>

Remember to prepare well and understand:
• the target pest
• your equipment
• your use of products and techniques.

Always read product labels and adhere to the instructions.
Can soil get sick?

Dr Rosalie Daniel, Plant Pathologist, NSW DPI, Ourimbah

Blueberry replant decline, disorder, disease, soil exhaustion or sickness?
Replant decline* has been reported in a wide range of crops including apples, asparagus, sugarcane, almonds, stone fruit, citrus and blueberries. Blueberry replant decline is emerging as a serious problem worldwide as older plantings are replaced and orchards become more intensive. The decline has been linked to nematodes, soilborne fungi and oomycetes (e.g. *Phytophthora*, *Rhizoctonia*, *Pythium*), bacteria (*Ralstonia*) and viruses. Research from Georgia in the USA found that nematode related losses can be up to 71% in some southern highbush orchards.

With the blueberry industry expanding, new orchards are being planted into soil that was previously used to grow blueberries or other horticultural crops, possibly for many years. New transplants often grow poorly or die. Pests and diseases can build up in an orchard, and while mature plants in established orchards are generally not affected, younger replants are more susceptible, resulting in poor establishment. Other soil factors such as pH, nutritional imbalances, soil moisture, organic matter, crop and chemical residues, weeds and time between replanting can contribute, and potentially exacerbate the problem.

*Replant decline of fruit tree crops is referred to by many names, including replant disease, replant decline, yield decline, replant syndrome, soil sickness and soil exhaustion. For consistency, here the reduction in plant vigour and yield, potentially resulting in plant death, following replanting of similar crops into the same soil is referred to as replant decline.

Blueberry replant decline symptoms
Uneven growth throughout the orchard, loss of vigour, wilting, stunting, leaf yellowing, defoliation, poor plant anchoring, early reddening, tip dieback and eventually plant death can all be signs of blueberry replant decline (Figure 1). Below ground, roots will be discoloured and there is a general reduction in root biomass. Replant decline can also have secondary effects. For example, affected plants will more readily succumb to other diseases, such as Botryosphaeria and those caused by other woody plant pathogens.

Blueberry replant decline causes
Because of the complex, variable nature of the causes, there is no quick test to confirm replant decline in an orchard. The perennial nature of orchards means that there is no opportunity to begin again each season. Without a clearly defined causative agent, an integrated approach is required. Pre-planting approaches generally involve manipulating the soil environment through:

• fumigation
• rotation crops
• increasing organic matter
• altering chemical status
• correcting soil chemical and physical issues
• improving the soil environment to favour beneficial microbes.

Post-planting, compost amendments and mulches can be used to promote soil microbes and healthy root growth.

Preventing blueberry replant decline
Fumigation is often used to kill soilborne pathogens before planting. Fumigation trials in blueberries resulted in significantly higher plant growth, vigour and yield, compared with those grown in soil that had not been fumigated before planting. Thus, it is likely that soilborne organisms are involved in replant decline.

The type of fumigant used can indicate which organisms might be involved. For example, where a nematicide is used and replant decline is not observed following planting (compared with a crop that has not been fumigated), then plant pathogenic nematodes are likely to be contributing to soil replant decline.

In some cases, where soil health contributes to decline, fumigation alone is not sufficient to support better plant growth. For example, in trials in blueberry orchards in Georgia USA, nematode levels were reduced to nearly non-detectable levels after fumigation. They increased over the next two growing seasons,
Can soil get sick?

but were still significantly lower than in non-fumigated soils. Adding pine bark to the soil before fumigation reduced nematode levels even further, extending the effectiveness of the fumigation treatment.

Biofumigation with *Brassica juncea* seed meal can control soilborne pathogens contributing to apple replant disease. Glucosinolates found in brassica leaves are toxic to soilborne pathogens (the roots of some brassicas can host some nematodes). The effectiveness varied with application time, rate and composition of the seed meal (Mazzola and Manici 2012). Ammonia from chicken manure is also toxic to many soilborne pathogens.

Break crops grown in the year before planting modify the soil environment, thus reducing replant decline in perennial crops. The effect depends on the rotation crop species used and the duration of the rotation. In Queensland, using rotation crops on land previously used for sugar cane for more than 20 years reduced nematode levels and increased yields to levels comparable with conventional fumigation (Garside et al. 1999).

It is important to understand the interactions between soil microbes and break crops to formulate effective non-chemical fumigant disease control strategies. Manipulating rhizosphere microbial communities can be achieved by inoculation with beneficial microbes such as *Bacillus subtilis*. Adding organic matter can create a soil environment that stimulates beneficial soil microbes that can antagonise or compete with pathogenic soil organisms. Composts, manures and mineral fertilisers have also been shown to control replant decline in some fruit crops.

Summary

Treatments are available to ameliorate replant decline. However, prevention is better than cure. Soil testing before planting can determine where corrections need to be made and also indicate how much time will be required for amendments to be applied and adjustments to take effect. Nematode testing can be done through Grow Help Australia (www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/agribusiness/grow-help-australia). Key management challenges include finding methods that are economically viable and sustainable so that the effects are retained for as long as possible. Identification of biological, soil and site factors contributing to decline is key. Ultimately, the soil is an ecosystem and its management requires an integrated pre- and post-replant approach.

References


Figure 1. Blueberry plants of the same variety (cv. Snowchaser), planted at the same time (images show blueberry plants 4 years after planting). Plants on the left are stunted and low yielding, leaves are often yellow, and foliage is sparse, with uneven growth across the block. The plants on the right are green, with dense foliage, and high yielding. Photo: Rosalie Daniels.
Managing your spray

Effective and efficient spray application is important for blueberry production. Spray liquid (concentration) and sprayer air outputs (coverage) need to be matched to different bush targets to deliver an effective chemical dose with sufficient target coverage. Timely and economic spraying is a trade-off between travel speeds and spray volumes to maximise spraying work rates without compromising target penetration and coverage. There are three basic rules to sprayer setup and spray optimisation:

1. **Direct the spray output towards the target canopy.** The main problem with spraying is failing to hit the target. To assess your spray output, park the sprayer in a block to be treated. Look at which nozzles should be turned on and what proportion of the output is directed to the different bush zones (Figure 2). Adjust nozzles as required for better coverage and use water sensitive paper (Figure 4) to help you assess the coverage.

2. **Adjust your spray water volume to match different canopies.** Dilute spray volume is required to calculate the correct amount of chemical to be applied to cover the canopy. Mixing the right concentration is just as important as determining the water volume required. An industry standard for water volumes in blueberries is presented in Figure 3. Chemical application rate is dependent on spray water volume (when using the per 100 L water rate) and spray water volume is dependent on crop canopy volume. For example, the total amount of Indoxacarb per hectare will vary when applied to different canopy volumes (Table 3). If spray water volumes are not matched to crop canopy volumes (i.e. less water than industry standard), chemical application rates should be adjusted (i.e. using a concentration factor) to achieve the same dose. Using these water volumes and the per 100 L label rate will achieve the most desirable amount of chemical per leaf area. Water sensitive paper should be used to verify these volumes and coverage.

3. **Penetrate the target by matching air output volumes to travel speed, canopy density and wind conditions.** Effective penetration is achieved by proper air movement at the correct fan and travel speeds. Poor coverage and excessive drift can occur when fan speeds are too high, blasting the droplets through the canopy. Poor coverage can also occur when the operator is driving too fast, causing improper air displacement. This prevents droplets from reaching the inner areas of the canopy.

<table>
<thead>
<tr>
<th>Canopy size</th>
<th>Water volume (L/ha)</th>
<th>Product (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>450</td>
<td>76.5</td>
</tr>
<tr>
<td>Medium</td>
<td>650</td>
<td>110.5</td>
</tr>
<tr>
<td>Large</td>
<td>850</td>
<td>114.5</td>
</tr>
</tbody>
</table>

Table 3. The amount of Indoxacarb per ha (17 g/100 L) varies when applied to different canopy volumes.

Figure 2. Croplands Quantum mister sprayer in blueberries. Note the angle of the setup to allow optimum coverage.

Figure 3. Different canopy volumes will require different water volumes.
Using water sensitive paper
Water sensitive paper (Figure 4) is an effective and economical way to monitor spray distribution. To test your coverage, place six pieces of water sensitive paper per plant, locating them on the top, middle and bottom and on the underside and top of the leaf surface, for multiple plants along a row. Generally, 85 fine–medium-sized droplets per square centimetre, with about 15% total surface coverage, should be adequate for most foliar applications. Be prepared to make changes to your sprayer calibration to compensate for plant height, canopy density and weather conditions throughout the season. Using water sensitive paper takes some time and effort but is far more accurate than ‘shoulder-checks’ and leaf residue.

![Figure 4. 85 droplets per square centimetre provides best coverage.](image)

Nozzles and droplet sizes
There is a trade-off between droplet size, spray drift and chemical coverage. The smaller the droplet, the greater the risk of spray drift but the better the coverage will be. Larger droplets will reduce spray drift but coverage will not be as effective (however, a good, low drift wetting agent can overcome this).

Rules of thumb with nozzles:
• Hollow cone nozzles produce smaller droplets and less size range than solid cone nozzles
• Wide angle nozzles produce smaller droplets than narrow angle nozzles
• Lower output nozzles produce smaller droplets than higher output nozzles

Larger droplets are preferable when spraying near sensitive areas (always follow the label recommendations). Combining large droplet size and a wetting agent will significantly reduce the risk of off-target drift. Some product labels state the size of the nozzle required and/or nominated buffer zones; both must be followed.

Calibration is an efficiency tool often overlooked and under-used by many growers. Over time, all nozzles suffer from wear and tear, causing their orifices to get bigger, increasing the desired or calibrated output. Uneven wear can cause poor spray patterns and poor control; both potentially causing crop damage. Regular sprayer calibration throughout the season based on bush growth will give greater spraying accuracy. For best results, calibrate your spray unit at the end of the growth phase (February – May depending on variety). Regularly cleaning nozzles improves delivery rates by removing debris build-up (Figure 5).

![Figure 5. Continually check and clean nozzles for best results.](image)

Summary checklist
• Ensure the spray operator is accredited and trained ([www.smarttrain.com.au](http://www.smarttrain.com.au))
• Use the correct water volume
• Identify the target pest
• Only use pesticides registered for the target pest
• Calibrate your equipment to reach the target with adequate coverage and dose, without drift
• Only spray when the pest is vulnerable and weather conditions are optimal (check temperature, wind speed and direction, humidity, rainfall). Avoid spraying when beneficial organisms might be present.
• Apply the product within the label guidelines
• Reach the target surface with adequate coverage and dose
• Record details of the spray application and conditions as per regulations (see example spray record form in Table 36 on page 67
• Visit [sprayers101.com/](http://sprayers101.com/) for more information on improving the efficacy, efficiency and safety of your spray applications.

Acknowledgements
Special thanks to Gaius Leong and George Mittasch from OzGroup Coop and Matt Moyle from Nufarm for their tireless efforts in helping to determine the water volumes for different sized blueberry plants and for developing a standard for the industry. Spray equipment and support was graciously provided by the OzGroup Coop’s growers.
Primary producers across Australia should be very familiar with the term ‘biosecurity’ and its importance in protecting our Australian industries and environment. However, familiarity with the term does not necessarily provide you with the know-how for implementation on-farm. To help you build upon your current practices and to contribute to the biosecurity of your industry, here is a summary of the key points.

Biosecurity – a legal responsibility
Biosecurity laws in NSW mean that everyone has an active role to play in managing biosecurity risks under their control. The introduction of the General Biosecurity Duty in NSW makes it more important than ever, to not only be aware of biosecurity risks to your property, but also to take action to mitigate these risks. A great way to monitor biosecurity threats to your property and to prioritise actions is by developing a farm biosecurity plan.

Farm biosecurity planning
Quick and simple measures can easily be built into everyday practices that will help protect your farm and your future from biosecurity threats.

NSW DPI has produced a Farm Biosecurity Planner for berry industries to help you identify biosecurity risks on your farm and provide guidance on how to address them. By developing a biosecurity plan you will be able to identify and prioritise biosecurity practices relevant to your property. One strategy might not suit all farms and the actual management practices you choose to use will vary depending on the parameters of your property(s).

To get started or to improve your own farm biosecurity plan, visit the Farm Biosecurity Planner for blueberries and other berry industries: https://abga.com.au/grow-berries/biosecurity/.

On-farm biosecurity risks
Biosecurity risks on-farm can generally fall into one of six essential categories. Actions identified in your farm biosecurity plan will help to improve biosecurity in these fundamental areas:

1. Farm inputs: Anything moved onto your property can be a source of pests and diseases. Monitor plant materials that enter the property as well as sources of water and fertilisers.

2. Farm outputs: Responsibility for biosecurity does not end when the produce leaves your farm gate. The measures in place on your property will support biosecurity in your region.

3. People, vehicles and equipment: If it can move, it can carry diseases, pests and weeds. Hence people, vehicles and equipment pose a high biosecurity risk and should be managed accordingly. For example, anyone coming onto your property should have clean and disinfested footwear (Figure 6).

4. Production practices: Good on-farm hygiene reduces the risk of spreading pests and diseases. Implement simple hygiene practices for water, product packaging, storage facilities, waste materials and plant propagation activities.

5. Weeds: These are a continuous biosecurity threat. Ensure you monitor and manage these widespread risks to your business.

6. Train, plan and record: Ensure staff are well trained, that you can trace where plants have come from and where they go, and keep records of purchases, sales and movements.

Figure 6. An example footbath.
Biosecurity pest threat spotlight – Blueberry leaftier

Blueberry leaftier (Croesia curvalana) is a small moth species that is not present in Australia. It has been labelled as one of the most destructive pests of blueberry crops in North America and poses a serious threat to Australia’s blueberry industry if it were to become established.

Damage
Blueberry leaftier larvae cause damage by feeding on developing flower buds, leaves and flowers. Young larvae cause the most serious damage by burrowing into developing flower buds to feed. They have been recorded to affect up to 20% of buds. Older larvae feed on the leaves and flowers. In severe outbreaks, defoliation can be close to 100%.

Description
Adult blueberry leaftier moths are small, about 6 mm long. When their wings are folded, the main colour that can be seen is a rusty red–brown, bordered by yellow margins. The body and head are yellow and two small yellow spots can be seen in the centre of the rust-coloured patch (Figure 7). Blueberry leaftier larvae are 5–7 mm long. Young larvae are cream coloured with a black head. Older larvae become yellowish with a cinnamon–brown head.

Life cycle
Female blueberry leaftier moths lay single eggs on leaf litter around the base of host plants. The eggs hatch mid–late spring. Newly hatched larvae climb into the blueberry plant to burrow into flower buds and begin to feed. Older larvae move from the flower buds to feed on expanding leaf buds, young leaves and mature flowers. The larvae spin silk to bend leaves to form a protective shelter while they feed (Figure 8). Pupation occurs in early summer, usually within the leaf shelter.

Host range
Blueberry leaftier is a known pest of low bush blueberry (Vaccinium angustifolium) and high bush blueberry (V. corymbosum). Other potential host species are currently unknown.

Spread
Blueberry leaftier moths can spread short distances by flying, although they usually restrict flight to within or beneath the canopy of host plants. Long distance spread of blueberry leaftier is most likely to occur with transporting infested plant material.

Distribution
Blueberry leaftier is native to and established across North America, including Canada.

Reporting
If you suspect blueberry leaftier, call the Exotic Plant Pest Hotline on 1800 084 881.
Blueberry development stages

Figure 9. Tight bud.

Figure 10. Bud swell.

Figure 11. Bud break.

Figure 12. Tight cluster.
Blueberry development stages

Figure 13. Early pink bud.
Figure 14. Late pink bud.
Figure 15. Full bloom.
Figure 16. Petal fall.
Figure 17. Green fruit.
Figure 18. Fruit colouring.
Managing blueberry diseases

Anthracnose

Cause
Anthracnose is caused by the fungi Colletotrichum simondsii and other Colletotrichum species. The pathogen overwinters on infected twigs, old fruiting spurs, live buds, infected prunings and fruit left in the orchard. In spring, spores are produced and released from blighted twigs and can continue to be released throughout the growing season.

Optimum development for Anthracnose occurs in moist conditions between 20–27 °C. Flowering is the most critical time for infection.

Symptoms
Infection begins during flowering. Infected fruit remain symptom-free until berries ripen. First symptoms can be the berry shrivelling and the characteristic sunken lesions will develop, particularly during warm, moist conditions. On ripe fruit, orange–pink spore masses form during humid conditions (Figure 19). Symptom development is often delayed until after harvest. Flower and twig blights, as well as leaf spots, can develop under very humid or moist conditions. Pink spore masses might also be observed on infected leaves, fruit stems, leaf stems and twigs.

Management

Cultural and physical
Clean harvest equipment thoroughly between infected and uninfected orchards. Regular pruning allows air circulation in the canopy and reduces drying time after the bushes have become wet. Remove all dead twigs, fruit and prunings from the orchard. Cool berries rapidly after harvest.

Chemical
Flowering is the most critical time for infection and appropriate chemical management. The chemical treatment options for Anthracnose in blueberries are outlined in Table 4.

Table 4. Chemical treatment options for Anthracnose in blueberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boscalid + pyroclorosbin (Pristine®) PER82986</td>
<td>7, 11</td>
<td>3</td>
<td>Low</td>
<td>Botrytis control sprays will also control Anthracnose. If rain is forecast and fruit is present, apply additional sprays.</td>
</tr>
<tr>
<td>Captan PER13958</td>
<td>M4</td>
<td>1</td>
<td>Low</td>
<td>Captan is preferable close to harvest due to its short WHP.</td>
</tr>
<tr>
<td>Copper PER84176</td>
<td>M1</td>
<td>1</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Cyprodinil + fludioxonil (Switch®) PER84891</td>
<td>9, 12</td>
<td>7</td>
<td>Low</td>
<td>Do not spray more than two consecutive sprays from the same chemical group.</td>
</tr>
</tbody>
</table>
Blueberry rust

Cause
The fungus *Thekospora minima* causes blueberry rust. Spores spread from old infections to infect new tissues. Infected leaves remaining on the plant after pruning become an inoculum source for new infections. Young leaves are most susceptible to infection.

Long periods of leaf wetness (e.g. seven hours at 21 °C) are required for infection to occur.

The fungus grows into the leaf and, depending on environmental conditions, pustules can develop from 10 days after infection. Spores are then moved by air or moisture to infect new tissues. Spore numbers can build up rapidly and there can be many infection cycles throughout a season.

Spores survive at least 4–8 weeks on leaves on the orchard floor, although viability declines over time. In favourable conditions, spores can be produced and dispersed at any time of the year. Spring through to autumn is the best time to check plants for signs of blueberry rust, especially when conditions are favourable for development.

Symptoms
Early signs of blueberry rust will appear as small chlorotic (yellow) spots on upper leaf surfaces (Figure 20). As the disease develops the spots become darker, red–brown and larger (Figure 21), then coalesce and become necrotic. Yellow–orange pustules develop on the corresponding lower leaf surface (Figure 22). The pustules contain spores that can infect new leaves. There can be thousands of spores in a single pustule (Figure 23). If the disease is severe, infected leaves can drop prematurely. Entire plants can be defoliated. Lesions and pustules can also form on fruit (Figure 24), reducing berry quality and marketability.
Management

*Cultural and physical*

Diligent hygiene practices will minimise the spread of rust. Where possible, growers should remove all diseased wood and leaves during pruning and dispose of all fallen and pruned leaves from branches. Pruning allows air circulation in the canopy and reduces drying time after bushes become wet (Figure 25).

*Chemical*

The chemical treatment options for blueberry rust are outlined in Table 5.

![Pruning allows air circulation and reduces drying time after bushes become wet.](https://example.com/image.jpg)

**Table 5.** Chemical treatment options for blueberry rust.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boscalid + pyroclostrobin (Pristine®)</td>
<td>PER82986</td>
<td>7, 11</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>PER14309</td>
<td>M5</td>
<td>28</td>
<td>Low</td>
</tr>
<tr>
<td>Copper</td>
<td>PER84176</td>
<td>M1</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>Dithianon</td>
<td>PER82601</td>
<td>M9</td>
<td>21</td>
<td>Low</td>
</tr>
<tr>
<td>Mancozeb</td>
<td>PER13958</td>
<td>M3</td>
<td>7</td>
<td>Medium</td>
</tr>
<tr>
<td>Propiconazole (Tilt®)</td>
<td>PER14740</td>
<td>3</td>
<td>3</td>
<td>Low</td>
</tr>
</tbody>
</table>
Botrytis

Cause

Botrytis cinerea is a fungus that causes blossom blight during flowering and fruit rot during postharvest handling and storage. Infections occur in the field during flowering, so this is the most effective time to implement controls.

Spores are produced in moisture and carried by air currents and water splash. Flowers are most susceptible shortly after they open, although earlier infection is possible. Slow pollination and ageing flowers can favour infection. Non-pollinated ovaries from which petals have shed are also highly susceptible to infection. They can remain attached for about 10 days and become a source of secondary inoculum. The fungus can grow from these ovaries into the stalk to infect other flowers and fruit in the cluster. It can also grow into the stem causing twig blight. Botrytis cinerea is always present, but causes serious losses when the weather is wet and cool for several consecutive days.

Infection is favoured by high relative humidity, fog and long wet periods. Studies have found that at 20 °C, only 6 hours of leaf wetness is required for infection.

Symptoms

Blossoms are the most susceptible tissue, turning brown when infected (Figure 26), after only a few days of high relative humidity. In continued humid conditions, masses of grey mycelium and spores are produced on blighted blossoms. Developing berries also become infected (Figure 27), but few rot in the field before harvest.

Figure 26. Blossoms infected by Botrytis cinerea.

Figure 27. Berries infected by Botrytis cinerea.
Management

Cultural and physical
Prune plants annually to keep the canopy open and improve air circulation. This will help with drying when the plant has become wet from dew or rain. Avoid excessive use of nitrogen fertiliser in the spring because the Botrytis fungus will readily infect succulent green growth. Cool berries rapidly after harvest and use sulfur pads in stacked trays.

Chemical
The chemical treatment options for Botrytis in blueberries are outlined in Table 6.

Table 6. Chemical treatment options for Botrytis in blueberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boscalid + pyroclostrobin (Pristine*) PER82986</td>
<td>7, 11</td>
<td>3</td>
<td>Low</td>
<td>Apply at early bloom or before flowers open. Additional sprays might be necessary when conditions favour the disease. Do not spray more than two consecutive sprays from the same chemical group.</td>
</tr>
<tr>
<td>Captan PER13958</td>
<td>M4</td>
<td>1</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Chlorothalonil PER14309</td>
<td>M5</td>
<td>28</td>
<td>Low</td>
<td>Do not spray more than two consecutive sprays from the same chemical group.</td>
</tr>
<tr>
<td>Cyprodinil + fludioxonil (Switch*) PER84891</td>
<td>9, 12</td>
<td>7</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Fenhexamid PER86489</td>
<td>17</td>
<td>1</td>
<td>Low</td>
<td>Do not exceed a maximum of four applications per crop per season. Do not use more than two applications sequentially before using another fungicide from a different MOA chemical group.</td>
</tr>
<tr>
<td>Iprodione (NSW, QLD, TAS and WA only)</td>
<td>B</td>
<td>1</td>
<td>Low</td>
<td>Spray at 10% blossom and full bloom. For fruit protection, apply 2-3 weeks pre-harvest.</td>
</tr>
<tr>
<td>Pyrimethanil (Scala*) PER13958</td>
<td>9</td>
<td>1</td>
<td>Low</td>
<td>Pyrimethanil at full strength will burn flowers. Do not use after early pink bud stage.</td>
</tr>
<tr>
<td>Sulfur dioxide pads PER13955</td>
<td>M</td>
<td>1</td>
<td>Low</td>
<td>Use sulfur pads in packed trays to reduce the incidence of Botrytis.</td>
</tr>
</tbody>
</table>
Crown gall

Cause
Blueberry crown gall is caused by the bacterium *Agrobacterium tumefaciens*.

Symptoms
Galls form at the bases of canes (Figure 28) or on major roots (Figure 29). They can also occasionally form on branches higher in the bush. Young galls are coloured cream to light brown and are spongy in texture. They turn dark, rough and harden with age. The bacterium enters through natural or mechanical wounds on stems and roots and induces gall formation. The disease is less of a problem in acidic soils.

Management
Managing crown gall involves:
- planting disease-free nursery stock in non-infested soils
- removing and destroying infected plants
- minimising wounding
- sterilising pruners
- maintaining proper soil conditions (e.g. pH 4.5 to 5.5).
Phytophthora root rot

Cause

*Phytophthora* species are fungus-like soilborne organisms that require moisture for reproduction and spread (i.e. oomycetes). The pathogen attacks the fine feeder roots of susceptible plants, compromising water and nutrient uptake.

Abundant soil moisture and temperatures between 20–32 °C promote disease development. Young roots are especially susceptible to infection.

Symptoms

Early symptoms are often above ground and include leaf yellowing and wilting, resembling drought or water loss (Figure 30). As the disease advances, stunting of terminal growth, leaf necrosis and plant dieback can occur. Below ground symptoms include young rootlet and crown necrosis, with the main roots turning reddish–brown. Disease symptoms might follow drainage lines as the pathogen can be spread by water. Bushes can eventually die (Figure 31).

Management

**Cultural and physical**

- Source new planting material from phytophthora-free nurseries.
- In heavy soils or high rainfall areas, grow blueberries on mounds with good drainage in the inter-row. In high rainfall areas, blueberry mounds should run up and down the slope for quick drainage rather than across the contours.
- Prepare new sites by mounding and improving soil organic matter using cover crops and manure. Ammonia and volatile organic acids released by decomposing organic material reduce phytophthora spores and stimulate beneficial microorganisms. Incorporating gypsum into planting sites also helps to act as a weak fungicide and reduces the number of spores in the soil.
- Avoid planting in poorly drained sites or improve the drainage before planting.
- Grow rooted cuttings or nursery plants on raised beds and avoid over-irrigating and ponding.
- Monitor irrigation to avoid over watering and water logging.

**Chemical**

The chemical treatment options for phytophthora root rot in blueberries are outlined in Table 7.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metalaxyl (Ridomil®) PER13958</td>
<td>4</td>
<td>48</td>
<td>Low</td>
<td>Apply directly to the soil and water in.</td>
</tr>
<tr>
<td>Phosphonic acid (Agrifos®, Phospot®) PER13958</td>
<td>33</td>
<td>Not required when used as directed.</td>
<td>Low</td>
<td>Use a maximum of three applications: • when new growth is 200–300 mm high • 7 days before first flower • 28 days before leaf fall in autumn.</td>
</tr>
</tbody>
</table>
Stem blight

Cause
Fungi associated with stem blight in Australia include *Neofusicoccum parvum*, *N. australe*, *N. oculatum*, *N. macroclavatum*, *Lasiodiplodia theobromae*, *L. pseudotheobromae* and *Botryosphaeria dothidea*. The fungi survive in infected wood and leaves of blueberry and other woody hosts. Spores produced on infected plant material are dispersed by air or water-splash to infect shoots, stems, branches and buds.

Symptoms
Infection usually begins in the branches. Symptoms include reddening leaves (Figure 32), necrosis on one or more branches, and a characteristic ‘flagging’ appearance of a dead branch with leaves still attached.

A pale brown–grey discoloration can be seen inside infected stems (Figure 33). In severe cases the infection progresses into the base of the plant, resulting in systemic branch dieback over a period of weeks or months, eventually killing the plant. Raised black fruiting bodies can occur on infected stems.

The fungi enter the host plant through wounds, including herbicide injury, pruning wounds and insect damage. They can also enter through natural openings such as growth cracks, leaf scars, lenticels (stem pores) and root to root contact. The fungi often remain latent in the plant, not causing symptoms until the plant becomes stressed.

Management
Source clean, disease-free planting material when establishing a new block or orchard. Avoid any activities which might stress or injure the plants, ensuring good irrigation and nutrition practices will help with management. Practice strict orchard hygiene measures. The best control is achieved by pruning out infected plant parts and removing them from the orchard. Prune at least 15–20 cm beyond diseased (discoloured) wood to prevent the infection spreading. Prune during dry periods to reduce spread. Disinfect tools between plants, especially if cutting through a diseased branch. Cutting at an angle when pruning can promote water run-off.

Ensure biosecurity best practices to prevent entry, establishment and spread of stem blight onto and from your property. Practice 'Come clean, go clean'.

Stem blight is favoured by high relative humidity, rainfall and a wide range of temperatures (5–35 °C) as well as plant stress and injury.

Figure 32. Reddening leaves caused by stem blight.

Figure 33. Stem blight discolouration.
Managing blueberry pests

Aphids

Pest identification
Most aphids are soft-bodied, pear-shaped and approximately 1–2 mm long (Figure 34).

Damage
Aphids prefer feeding on tender growing shoots, causing new growth to deform, wilt and defoliate. High infestations can reduce fruiting bud formation for the following year’s crop. Aphids produce copious amounts of honeydew, making the leaves and fruit sticky, sensitising plant tissue to sunburn and promoting sooty mould growth.

Management
Look for aphids on areas of the bush with tender tissue such as new branch growth, buds, shoots, both sides of the leaves and into leaf curls.

Cultural and physical
Aphid populations increase rapidly on most plants receiving excess nitrogen. Regulate nitrogen fertilisers for optimum, but not excessive, growth and vigour. Prune if needed to remove excess growth.

Biological
Release predatory arthropods and create inviting habitats for beneficial insects. The main aphid predators include common hoverflies, green lacewings (Figure 35), assassin bugs and ladybirds (Figure 36). Parasitic wasps such as A. colemani, A. ervi and Aphelinus abdominalis are commercially available for release.

Chemical
The chemical treatment options for aphids in blueberries are outlined in Table 8.

Table 8. Chemical treatment options for aphids in blueberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethoate</td>
<td>1B</td>
<td>1</td>
<td>High</td>
<td>Apply in the afternoon when bees have finished foraging.</td>
</tr>
<tr>
<td>Horticultural mineral oil</td>
<td>NA</td>
<td>1</td>
<td>Low</td>
<td>Do not spray mineral oils if leaf temperatures are 26 °C or greater.</td>
</tr>
<tr>
<td>Primicarb</td>
<td>1A</td>
<td>2</td>
<td>Low</td>
<td>–</td>
</tr>
</tbody>
</table>
Elephant weevil

**Pest identification**
The elephant weevil’s (*Orthorhinus cylindrirostris*) body is densely covered with scales that can vary from grey to black (Figure 37). The weevils can be up to 20 mm long. The larva is soft, fleshy, creamy yellow and legless.

**Damage**
The females bore holes into blueberry plant stems to lay eggs. The larvae hatch and feed by boring tunnels through the stem, crown and roots of the plant. As larvae exit the plant to mature, they leave large emergence holes at the base of the plant (Figure 38).

*It is the larval stage that causes the most economic damage. Adults emerge from September to February when they climb onto upper branches, usually a few weeks after pruning, and mate. This is the optimum time for control.*

**Management**

**Cultural and physical**
Monitor for borer attack signs. Rapidly remove and destroy all infested bushes and material thoroughly to prevent premature metamorphosis and emergence of any weevils in the bushes. Removing adults might help break population cycles.

Some blueberry varieties (e.g. MBO 11‑11, Star, Costa cv. 42) are more attractive to elephant weevil than others, so monitor these carefully.

Practices that reduce stress (such as fertilisation and irrigation) are essential in droughts to reduce the susceptibility of bushes.

**Chemical**

Chemical treatment (Table 9) is most effective when the adults emerge and climb on to the upper branches of recently pruned plants.

![Figure 37. Adult elephant weevil.](image)

![Figure 38. Elephant weevil exit damage. Photo: M. Rocchetti, Costa Berries.](image)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifenthrin PER84972</td>
<td>3A</td>
<td>1</td>
<td>Medium</td>
<td>Apply 7 days after pruning or when adults have emerged and are observed on cut surfaces or foliage of pruned plants. A follow-up spray 7-10 days later might be required for later emerging beetles.</td>
</tr>
<tr>
<td>Indoxacarb PER13289</td>
<td>22A</td>
<td>3</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Chemical treatment options for elephant weevil in blueberries.
Lepidoptera

Pest identification
A number of lepidoptera species e.g. mango webworm (*Dudua aprobola*), cotton bollworm (*Helicoverpa armigera*), native budworm (*H. punctigera*; Figure 39) and orange fruit borer (*Isotenes miserana*; Figure 40) can cause damage to blueberries.

![Native budworm moth](Image)

Figure 39. Native budworm moth.

![Orange fruit borer](Image)

Figure 40. Orange fruit borer. Photo: Todd M. Gilligan and Marc E. Epstein, Tortricids of Agricultural Importance, USDA APHIS PPQ, Bugwood.org.

The native budworm can migrate at high altitudes over large distances (100–1,000 km) each night. The moths fly from areas where conditions do not favour another generation, to where there are abundant food plants for further breeding. They fly up into the warm northerly or north-westerly winds and migrate to the southern and eastern regions during early spring.

![Damsel bug](Image)

Figure 42. Damsel bug, a predator of lepidoptera. Photo: Phil Sloderbeck, Kansas State University, Bugwood.org.

Damage
Lepidoptera larvae cause the most damage. After hatching, the caterpillar crawls around the plant feeding from its surfaces (Figure 41), particularly tender tissues such as plant tips, flowers and fruit.

![Orange fruit borer leaf damage](Image)

Figure 41. Orange fruit borer leaf damage.

Management

**Biological**
Predators and parasitoids such as predatory shield bugs (*Podisus* spp.), Tachinid fly (*Tachinidae* spp.), green lacewings (*Mallada signata*), brown lacewings (*Micromus tasmaniae*), damsel bugs (*Nabi kinsbergii*; Figure 42) and Trichogramma pretiosum are all biological control options for lepidoptera. Lacewing eggs (Figure 43), once hatched the larvae are wide-ranging predators that will attack and eat small caterpillars, aphids and mites. *Bacillus thuringiensis* (Bt) is a bacterium that affects the caterpillar stage of lepidoptera insects and is commercially available as an insecticide.
Managing blueberry pests

Figure 43. Lacewing eggs, once hatched the larvae are wide-ranging predators that will attack and eat small caterpillars, aphids and mites. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

Chemical

A range of pheromone lures (Figure 44) are available for monitoring pest moth activity such as codling moth and native budworm. This provides early warning of the arrival or emergence of the pest and an indication of pest pressure to be expected throughout the season. This information should be used to improve pest management decisions. The chemical treatment options for lepidoptera in blueberries are outlined in Table 10.

Figure 44. A reusable weatherproof delta trap for use with pheromone lures to monitor moth populations. Photo: www.bugsforbugs.com.au.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacillus thuringiensis</strong> (Bt)</td>
<td>11</td>
<td>Nil</td>
<td>Low</td>
<td>Bt must be ingested by the target insect; thorough coverage is essential.</td>
</tr>
<tr>
<td>Chloranthraniliprole PER84178</td>
<td>28</td>
<td>3</td>
<td>Low</td>
<td>Do not apply more than three applications per crop, with a minimum retreatment interval of 7 days between sprays.</td>
</tr>
<tr>
<td>Emamectin PER85422</td>
<td>6</td>
<td>5</td>
<td>Medium</td>
<td>Do not spray any plants with emamectin while bees are foraging.</td>
</tr>
<tr>
<td>Methomyl</td>
<td>1A</td>
<td>5</td>
<td>High</td>
<td><strong>On label for blueberries in NSW and WA only. A permit is required for QLD (PER14134).</strong></td>
</tr>
<tr>
<td>Spinetoram</td>
<td>G5</td>
<td>1</td>
<td>Medium</td>
<td>Use the higher rate in dense canopies and when larvae have begun webbing leaves and fruit. Use the lower rate under an IPM system or where good coverage is assured.</td>
</tr>
</tbody>
</table>
**Light brown apple moth**

**Pest identification**

The light brown apple moth (LBAM; *Epiphyas postvittana*) is a native Australian leaf-roller (Figure 45). The moths are pale brown (Figure 46) with a wingspan of about 10 mm. Caterpillars are yellow when young 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. Light brown apple moth do not survive well at high temperatures. Thus they are a more serious problem in cooler areas with mild summers.

![Figure 46. Light brown apple moth adult.](image)

**Damage**

Larvae feed on the leaves, buds, flowers and berries. Their feeding on berry surfaces under webbed leaves causes scarring as well as providing a site for rot or infection (Figure 47).

![Figure 47. Fruit damage from light brown apple moth.](image)

**Management**

**Cultural and physical**

Reduce weeds such as dock and capeweed (Figure 48) because LBAM survive on these weeds during winter.

![Figure 48. Capeweed can host light brown apple moth during winter. Photo: Joseph M. DiTomaso, University of California Davis, Bugwood.org.](image)

**Biological**

Monitoring using commercially available pheromone traps (Figure 49) provides early warning of the arrival or emergence of LBAM, helping with early control and management. Monitoring should start early in the season e.g. August.

![Figure 49. Commercially available pheromone trap being used for LBAM monitoring.](image)
Trichogramma carverae are commercially available parasitic wasps for controlling LBAM. Natural enemies such as other parasitic wasps, lacewings, spiders and predatory shield bugs also contribute to overall biological control.

Bacillus thuringiensis (Bt) is a naturally occurring, commercially available soilborne bacteria that is toxic to LBAM larvae when consumed.

Pheromone isomate wire ties (Figure 50) placed in the orchard at a rate of 500/ha are effective non-chemical mating disrupters. They work by flooding the orchard with a pheromone that confuses the male. It does not kill the adult or any stage of the LBAM life cycle, but disrupts the mating behaviour.

Chemical

The chemical treatment options for LBAM in blueberries are outlined in Table 11.

Table 11. Chemical treatment options for LBAM in blueberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus thuringiensis (Bt) (Dipel®)</td>
<td>11</td>
<td>Nil</td>
<td>Low</td>
<td>Bt must be ingested by the target insect; thorough coverage is essential.</td>
</tr>
<tr>
<td>Chlorantraniliprole PER84178</td>
<td>28</td>
<td>3</td>
<td>Low</td>
<td>Monitor crops and apply when populations reach determined economic thresholds.</td>
</tr>
<tr>
<td>Emamectin PER85422</td>
<td>6</td>
<td>5</td>
<td>Medium</td>
<td>Do not spray any plants with emamectin while bees are foraging.</td>
</tr>
<tr>
<td>Indoxacarb PER13289</td>
<td>22</td>
<td>3</td>
<td>Medium</td>
<td>Do not spray any plants with indoxacarb while bees are foraging.</td>
</tr>
<tr>
<td>Methomyl</td>
<td>1A</td>
<td>5</td>
<td>High</td>
<td>On label for blueberries in NSW and WA only.</td>
</tr>
<tr>
<td>Methoxyfenozide (Prodigy®)</td>
<td>18</td>
<td>7</td>
<td>Low</td>
<td>Target eggs and newly hatched larvae.</td>
</tr>
<tr>
<td>Spinetoram</td>
<td>G5</td>
<td>1</td>
<td>Medium</td>
<td>Use the higher rate in dense canopies and when larvae have begun webbing leaves and fruit. Use the lower rate under an IPM system or where good coverage is assured.</td>
</tr>
</tbody>
</table>
Queensland fruit fly

**Pest identification**
Adult Queensland fruit flies (QFF; *Bactrocera tryoni*) are about 6–8 mm long and are reddish-brown with yellow markings (Figure 51). They are most active in warm, humid conditions and after rain. QFF lay eggs in maturing and ripe fruit on bushes and sometimes in fallen fruit.

![Figure 51. Queensland fruit fly adult.](image)

**Damage**
The larvae hatch, then their feeding and the associated decay destroys the fruit (Figure 52).

![Figure 52. Queensland fruit fly larvae in a blueberry. Photos: John Golding.](image)

**Management**
A single control method is not sufficient to eradicate QFF from an area. Best results are gained from a combination of methods such as population monitoring by trapping, area saturation with male annihilation technology (using pheromones to attract and kill males), protein bait sprays and strict orchard hygiene practices.

**Cultural and physical**
**Monitor** using fruit fly traps to determine population trends (Figure 53). To improve the efficacy of the traps, replace the wicks every three to six months (depending on product). Start monitoring in spring and continue throughout the year until winter. Monitoring over time provides information on fly behaviour, where to focus your efforts and an assessment of your management strategies.

**Orchard hygiene** is essential as bushes with fallen and rotting fruit are a source of fruit fly infestations. Fruit flies can travel several hundred metres, so infected fruit should not be left within one kilometre of the orchard. Practice good packing shed hygiene with thorough inspections to remove any infested fruit and disposing of it appropriately.

![Figure 53. Fruit fly trap used to monitor QFF populations.](image)

**Male annihilation technology** (MAT) is an ‘attract and kill’ strategy for male flies. The aim is to reduce male populations to low levels, thus reducing mating opportunities for females. The technique involves distributing devices containing Cue-Lure (male attractant) and an insecticide. Place the lures throughout the crop and in alternative hosts (i.e. fruiting windbreaks) at a density of about 16–20 per hectare. Additional lures should also be placed every 20 metres around the perimeter of the property early in the season (late winter) to reduce the number of male flies entering the orchard. New lures should be placed into your orchard three times a year, and each MAT device should be left in the field for 12 months. Amulet® Cue Lure and Bugs for Bugs MAT devices (Figure 54) are commercially available.

Both male and female QFF need protein to reach sexual maturity, therefore **protein bait spraying** is an effective control method. It involves using a protein source (e.g. yeast...
autolysate PER13785) to attract QFFs and an insecticide (e.g. maldison or trichlorfon) to kill them. Begin spraying as soon as traps indicate QFF are present or fruit is at a susceptible stage. Apply bait sprays to the trunks of bushes or on trellis posts (Figure 55) where QFF are likely to be active. Do not spray the fruit to avoid concerns about residue and fruit damage. Repeat applications every seven days, or sooner if rain has washed off the mixture.

Figure 54. Orange MAT cup. Photo: bugsforbugs.com.au.

Figure 55. Protein bait spray on a trellis post. Photo: area-wide-management.com.au.

**Chemical**
The chemical treatment options for QFF in blueberries are outlined in Table 12.

Table 12. Chemical treatment options for Queensland fruit fly in blueberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abamectin PER14423</td>
<td></td>
<td>6</td>
<td>7</td>
<td>High Apply as a strip or spot treatment with yeast autolysate.</td>
</tr>
<tr>
<td>Dimethoate 1B</td>
<td></td>
<td>1</td>
<td>1</td>
<td>High On label for use in NSW and WA only.</td>
</tr>
<tr>
<td>Maldison (Fyfanon® 440 EW)</td>
<td>1B</td>
<td>3</td>
<td>3</td>
<td>High Apply as a spot or strip spray. For spot spraying apply 100–150 spots/ha using 50–100 mL/spot of bait solution.</td>
</tr>
<tr>
<td>Spinetoram PER12927</td>
<td>5G</td>
<td>1</td>
<td>Medium</td>
<td>Thoroughly apply foliar cover spray after flower set depending on pest pressure as determined by regular crop scouting and fruit fly trapping. Do not apply more than four applications each season, with a minimum of 7–14 days between consecutive (repeat) sprays.</td>
</tr>
<tr>
<td>Trichlorfon 1B</td>
<td></td>
<td>2</td>
<td>Medium</td>
<td>Medium Can be used as a cover spray with a maximum of three applications each season. Registered on label for blueberries in NSW but a permit (PER12486) is required for all other states.</td>
</tr>
</tbody>
</table>
Red-shouldered leaf beetle

Pest identification

Red-shouldered leaf beetles (Monolepta australis) are 6 mm long and yellow, with a dark red band across the shoulders and two purple spots on the ends of their wing covers (Figure 56). Their yellowish eggs are small and oval. The larvae are white, slightly flattened with hard brown plates at both ends and reach 10 mm in length.

Damage

Adult beetles attack leaves, fruit (Figure 57) and flowers. High populations will shred leaves (Figure 58) and strip plants of flowers. Infestations are likely after heavy rainfall (20–40 mm) in spring and summer. The beetles enter orchards from prevailing winds and collect on a few plants before dispersing.

Management

Chemical

Effective control can be achieved if incursions are discovered early and are spot-sprayed before they disperse to the rest of the orchard. Check crops after heavy rainfall as populations of greater than 20 beetles per square metre will cause significant damage.

The chemical treatment options are in Table 13.

Table 13. Chemical treatment options for red-shouldered leaf beetles in blueberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methomyl</td>
<td>PER14134</td>
<td>1A</td>
<td>5</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apply to plants when the swarm is present. On label for use on blueberries in NSW and WA only.</td>
</tr>
<tr>
<td>Pyrethrin</td>
<td>PER80070</td>
<td>3A</td>
<td>Not required when used as directed.</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ensure adequate coverage and penetration to obtain effective control.</td>
</tr>
</tbody>
</table>
**Scale (wax) insects**

**Pest identification**
Scale are insects that feed on plant tissue and secrete honeydew. The term ‘scale’ refers to the substance secreted over the back of the insect. The white wax (Figure 59) is seen around autumn when the adults settle, so growers should treat plants when the insects are crawlers. Scale insects often do not have functional legs; adult females are generally sedentary. Most species lay eggs underneath their body.

**Damage**
Scale insects feed on young growing tips, causing distorted foliage. Feeding on leaves causes leaf yellowing and the plant appearing stressed and stunted. If left uncontrolled, scale can weaken the bush, predisposing it to disease or abiotic problems. Scale on fruit might cause blemishes or distortions, especially if infestations occur on developing fruit. The honeydew secreted by scale often causes sooty mould growth, which if on fruit, can make it unsaleable.

**Management**
Managing scale insects should focus on preventing infestations and controlling populations before they cause economic loss. Monitoring should include visual observations, including turning over leaves, looking for black sooty mould and ants on the plants.

**Cultural and physical**
Pruning old, weak canes and scale infested wood prevents scale populations from increasing and removes a large pool of eggs.

**Biological**
There are a number of natural enemies for managing scale insects. Some are commercially available predatory insects (e.g. ladybirds such as *Cryptolaemus* (Figure 60) and blue chilocorus ladybird (*Chilicoris circumdatus*), naturally occurring parasitoid wasps (e.g. *Aphytis lingnanensis* and *A. melinis*) and predators such as green lacewings (*Mallada signata*).

**Chemical**
The chemical treatment options for scale insects are outlined in Table 14.

---

**Table 14. Chemical treatment options for scale in blueberries.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diazinon</td>
<td>1B</td>
<td>14</td>
<td>High</td>
<td><strong>On label for use in NSW and WA only.</strong> Spray in late afternoon after bees have finished foraging.</td>
</tr>
<tr>
<td>Parraffinic oil or Petroleum oil</td>
<td>NA</td>
<td>1</td>
<td>Low</td>
<td>Do not spray oil if leaf temperatures are greater than 26 °C.</td>
</tr>
<tr>
<td>Spirotetramat PER82607</td>
<td>23</td>
<td>7</td>
<td>Low</td>
<td>For white wax scale only. Apply at the onset of crawler emergence (spring to late summer) or when pest numbers reach economically damaging levels.</td>
</tr>
</tbody>
</table>
Scarab beetle

Pest identification
The African black beetle (*Heteronychus arator*; Figure 61) and various cockchafers belong to the scarab family. Larvae are usually cream, white or light brown. When they hatch they are small (1–3 mm long), but generally develop until they are longer than the adult. Many species of scarab larvae appear similar and often curl into a characteristic C-shape when disturbed or at rest (Figure 62). They have three pairs of well developed legs and usually a hard, brown, dark red or black head. Adults can vary in appearance, often being brown or black but can be green, yellow or red and are sometimes iridescent. Most scarab beetles are approximately 8–20 mm long.

Damage
Risk periods for scarab beetles include summer and early autumn, especially those with dry springs and summers; this is when populations build up. Most damage is caused by the larvae feeding on the underground roots of young plants. Adults often kill growing points so that the central shoots wither and the plants become dead-hearted. As they emerge (usually around December), African black beetles crawl up plants to feed and mate rather than go into the soil. This is when damage can occur to the young stems of newly established plants. The damage that scarabs cause is often difficult to diagnose, other than seeing signs of stress to the below-ground parts of the plant.

Management

**Biological**
The entomopathogenic nematode (*Heterorhabditis zealandica*) can be applied to scarab beetle larvae and is commercially available through retail outlets. It is recommended to apply this to populations of small larvae.

**Chemical**
Because chemical treatment should focus on preventing larvae from feeding on young plants, chemicals should be applied at planting and before root flushes each year.

The chemical treatment options for scarab beetles are outlined in Table 15.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorpyrifos PER82022</td>
<td>1B</td>
<td>Not required when used as directed.</td>
<td>High</td>
<td>Place pellets in the bottom of the planting hole and mix in well. Repeat if necessary in autumn and spring.</td>
</tr>
<tr>
<td>Imidacloprid PER12534</td>
<td>4A</td>
<td>Not required when used as directed.</td>
<td>Medium</td>
<td>Soil application only to be applied after harvest and before flowering begins the next season.</td>
</tr>
</tbody>
</table>
Thrips

Pest identification
Thrips are small, ranging from 0.5–2 mm, but can be up to 14 mm long. They are cylindrical and the head can be narrower than the rest of their body (Figure 63). Adults can be winged or wingless. When present, both pairs of wings are slender, with long comb-like hairs.

Damage
Eggs are laid in slits made in leaves and growing points. Nymphs and adults feed in growing points and inside flowers. Thrips usually blow into properties on hot winds, typically during October. Signs include discolouration and indents on the leaves (Figure 64), and damage to buds and flowers, which can result in fallen fruit. Some species will exclusively feed within flowers, others will feed on flowers, leaf buds and expanding leaves.

Management
Thrips are best detected by shaking flowers upside down over a sheet of paper or onto one’s hand. If more than five are detected in 10 flowers, then treatment is necessary. Increase the frequency of monitoring during expected periods of infestation, e.g. spring and summer, particularly during periods with strong winds.

Cultural and physical
Broadleaf weeds are an alternative host for Western flower thrips (WFT), so prevent these from flowering.

Biological
Neoseiulus cucumeris and Typhlodromips montdorensis are predatory mites (Figure 65) available for thrips control. Basil can be planted throughout orchards to act as a banker plant for thrips predators and a trap plant for thrips. Use approximately 200 bankers/ha (more or less depending on thrips pressure). Lacewing larvae and ladybird beetles also prey on thrips.

Table 16. Chemical treatment options for thrips in blueberries.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plague thrips</td>
<td>Methomyl (on label for blueberries in NSW and WA).</td>
<td>1A</td>
<td>Not required when used as directed.</td>
<td>High</td>
<td>Apply when thrips are numerous on flowers. Do not apply while bees are actively foraging.</td>
</tr>
<tr>
<td>Plague thrips and WFT</td>
<td>Dimethoate</td>
<td>1B</td>
<td>1</td>
<td>High</td>
<td>Ensure a minimum retreatment interval of 21 days between consecutive applications.</td>
</tr>
<tr>
<td>Western flower thrips</td>
<td>Spinetoram</td>
<td>5B</td>
<td>1</td>
<td>Medium</td>
<td>Spinetoram should be used as part of the western flower thrip resistance management strategy.</td>
</tr>
</tbody>
</table>
Frost injury

Identification and damage

Significant frost damage to fruit can usually be detected three to five days after exposure. Less severe damage during pollination can take up to 14 days to be noticeable. To determine the extent of frost damage, dissect developing fruit (post petal fall through to small peasized green fruit) with a sharp knife. Three to five days after frost is the ideal time to do this.

Common signs of frost damage include:
• Corolla damage, brown shrivel and drop (Figure 66)
• Internal browning of fruit (from small developing fruit through to ripe berries; Figure 67)
• Irregular colouring and ripening of berries
• Water soaked or irregular colour to fruit calyx (Figure 68)
• Irregular and misshapen berries (carried over from flower or developing fruit damage; Figure 69).

Figure 66. Corolla damage. Photo: MS Fruit Extension.

Figure 67. Internal browning of fruit. Photo: Bill Cline, North Carolina State University.

Figure 68. Water soaked and irregular colour to fruit calyx. Photo: Australian Blueberry Growers Association.

Figure 69. Irregular and misshapen berries. Photo: Australian Blueberry Growers Association.
Temperatures

The temperature at which freeze injury occurs will depend on the berry development stage. As flower bud swell progresses, cold tolerance decreases. By the time individual flowers start to protrude from the bud, temperatures below -7 °C can damage the most exposed flowers. When corollas have reached half of their full length, temperatures below -5 °C will kill the complete flowers. Blossoms on Rabbiteye blueberries can receive corolla damage when temperatures are at -1 °C. The exposure during this period will cause the corolla to wither, but it usually remains attached.

Immediately after corolla drop and before the berry begins to swell is one of the most sensitive stages. On open blossoms, more than a few minutes at -1.5 °C can cause damage. A few minutes at below -2 °C is high risk for damage. As the berry begins to enlarge, susceptibility is similar to the critical temperature of -2 °C for open blossoms.

Cold damage is not always immediately obvious. Following temperatures well below the critical levels, flowers or small fruit will develop a water-soaked appearance, shrivel and drop. However, a very brief time at the critical temperature might damage only the pistil. All or a portion of the damaged pistil will turn brown, prevent pollination and fruit set.

Ovules, which develop into the seeds within the berry, can also be damaged without any exterior symptoms. Healthy ovules are plump and white, but become black with cold injury. If a large number of ovules or young seeds are black, the flower or fruit will probably drop. Seeds produce hormones that help fruit to develop, so if only a few are damaged, fruit development usually continues, but the fruit will be later ripening and smaller than berries with a larger number of healthy seeds.

Management strategies

Orchard layout

Design your orchard to avoid frost problems. Leave a shelter belt above the orchard to restrict cold air coming into the orchard. Plant a windbreak to protect the orchard from cold winds. Arrange rows to allow for cold air to move through and drain out of the orchard. Use late flowering species and cultivars in frost prone locations.

Frost machines

On clear, calm nights, a strong temperature inversion develops, where temperatures within 1.8 m of the ground can become much colder than temperatures 15–30 m above ground. By mixing these air layers, wind can raise the temperature near the ground by about 15 °C. The exact amount will vary with the strength of the temperature inversion and the effectiveness of the air mixing. A single wind machine (Figure 70) normally provides a maximum increase in temperature of about 15 °C over an area of about 4 hectares.

![A wind machine in a blueberry orchard.](image)

Maintain soil moisture

Increasing the amount of water in the soil will enable it to absorb more heat during the day and to conduct more heat to the surface for plant protection. When soils are dry, they hold very little heat and a dry surface acts as an excellent insulator to prevent beneficial heat release. Excess water for extended periods must be avoided to prevent flooding and root rot damage.

Ground cover and weeds

A thick matt of grass, weeds or mulch on the soil surface will reduce solar soil heating as well as heat release from the soil at night. However, this can make frosts cause more damage. Therefore, delay applying mulches until the risk of frosts has passed. Ensure weeds are well controlled with their foliage totally decayed or removed before winter.
**Blueberry nutrient disorders**

**Phosphorus deficiency**
When phosphorus deficiency occurs, plants can become stunted with small leaves that will be tinted dark green to purple, particularly on the tips and margins. Leaves will be small and rounded, lying unusually flat against the stems and twigs (Figure 71), which will be narrow and can be reddish–purple.

**Boron deficiency**
Boron is a common deficiency for blueberries planted on mounded soils, as it is required by plants in very small amounts but is used up first. Beware of applying too much as toxicity can also be a problem. The rule is small amounts often. Boron most readily affects growing tips (Figure 72) and flowers as the plant cannot extract enough from the soil. Foliar fertilisers can help reduce this.

**Copper deficiency**
Copper deficiency in plants can lead to dead shoot tips in rapidly growing plants. This typical ‘gooseneck’ is evidence of copper deficiency (Figure 73). Copper deficiency can be easily eliminated by applying at least one copper fungicide spray during the growing season.
Potassium deficiency
Potassium deficiency symptoms can include tip dieback of shoots, scorching along the leaf margins (Figure 74), leaf cupping or curling and necrotic spots. Symptoms look similar to those of drought stress. Potassium deficiency is rare on most north coast soils, but some red soils can tie up large quantities of potassium. This can be easily corrected with regular foliar applications of mono-potassium phosphate during winter.

Magnesium deficiency
Magnesium deficiency results in a distinctive pattern of chlorosis that develops between the main veins in leaves. These regions can turn yellow to bright red while tissue beside the main veins remain green (Figure 75). Older leaves at the bases of canes and shoots show symptoms first. Young leaves at the tips of shoots are rarely affected.

Iron-induced chlorosis
Iron chlorosis is common when soil pH is above 5.5. High pH prevents the plants from using iron normally. Symptoms appear first at the shoot tips on young leaves. Tissue between veins is a light yellow or bronze-gold colour (Figure 76), while the leaf veins stay green. In severe cases all leaves are affected and leaf margins turn brown and die. Shoot growth and leaf size are reduced. Symptoms are increased if soils are compacted or poorly drained. These symptoms usually show up if large quantities of calcium are applied, increasing the soil pH. However, it can be corrected and verified by a foliar spray of iron chelates, which will change leaf colour within a few days if it is iron deficiency.
Blueberry pest management calendars

Most pests and diseases that affect blueberries appear during specific growth stages of the crop. This guide lists the most common conditions that growers should be looking for during a typical growing season in both Northern (Table 17) and Southern highbush (Table 18).

Table 17. Northern highbush (late) blueberries – likely timing for monitoring and treatment of pests as indicated by the blue shading.

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Flowering</th>
<th>Harvest</th>
<th>Postharvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botrytis flower blight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downy mildew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey mould (<em>Botrytis</em>)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pests</th>
<th>Flowering</th>
<th>Harvest</th>
<th>Postharvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common garden snail</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slugs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western flower thrips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland fruit fly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caterpillars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European wasp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light brown apple moth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loopers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 18. Southern highbush (early) blueberries – likely timing for monitoring and treatment of pests as indicated by the blue shading.

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Flowering</th>
<th>Harvest</th>
<th>Postharvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botrytis flower blight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plague thrips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey mould (<em>Botrytis</em>)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthracnose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Septoria leaf spot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spur blight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downy mildew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Budworms (<em>Helicoverpa, Heliothis</em>)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caterpillars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scarab beetle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesser Queensland fruit fly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland fruit fly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common garden snail</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slugs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dried fruit beetles (<em>Carpophilus</em>)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant weevil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light brown apple moth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loopers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red-shouldered leaf beetles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western flower thrips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aphids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African black beetle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spider (red) mites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale (wax) insects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Painted apple moth (hairy)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Over more than 12 years SLTEC® has become an industry leader in the formulation of Liquid Nutrient Solutions for the Berry Industry

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Raspberry development stages

Figure 77. Raspberry bud.

Figure 78. Raspberry bloom.

Figure 79. Bloom to green fruit.

Figure 80. Green fruit.

Figure 81. Green to ripe fruit.
They don’t just deliver reliable substrate, they add value too.”

I have no problems when it comes to cultivating outdoors. With the strong substrate specifically developed for me by Legro, I get optimal performance from my crop every time. It’s the perfect mixture and always reliable. For me, there’s nothing better than working with a company you can trust. So if that’s what you’re looking for, I’d say pick up the phone and call Legro.

Leon Driessen, Driesvenplant B.V., customer Legro
Managing raspberry and blackberry diseases

Anthracnose

Anthracnose is caused by the fungus *Elsinoë veneta*. Anthracnose, or cane spot, usually affects plant stems, but can also affect the leaves and fruit. The pathogen overwinters on infected twigs and leaves. Anthracnose can be introduced by infected plants or by spores that are dispersed by rain or water, blown in on the wind, or transported on contaminated clothing, vehicles or machinery.

**Symptoms**

On leaves, anthracnose symptoms appear as irregularly shaped, yellow spots. These spots enlarge and develop grey centres with reddish-purple borders (Figure 82). Over time these grey centres can fall out, giving the spots a shot-hole effect. Symptoms begin as small, distinct purplish spots on younger stems. The spots increase in size and their centres turn grey, while the outer edge stays purple (Figure 83). In severe cases, the spots join together, causing the stem to become weak and, in some cases, die.

**Management**

*Cultural and physical*

Control of anthracnose begins with clean, disease-free planting material, promoting good air movement by keeping fruit rows narrow, spacing canes adequately and controlling weeds.

*Chemical*

Table 19. Chemical treatment options for anthracnose in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin (PER84970)</td>
<td>11</td>
<td>1</td>
<td>Low</td>
<td>Begin applications at disease onset. Only use a maximum of three applications each season. Do not apply more than two consecutive applications with a retreatment interval of 14 days.</td>
</tr>
<tr>
<td>Bosalid + pyroclostrobin (Pristine®) (PER82986)</td>
<td>7, 11</td>
<td>1</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Copper as oxychloride (raspberry only)</td>
<td>M1</td>
<td>1</td>
<td>Low</td>
<td>Apply at bud movement.</td>
</tr>
</tbody>
</table>
**Botrytis**

**Cause**

*Botrytis cinerea* and other fungal *Botrytis* species cause Botrytis blossom blight, grey mould and cane botrytis. *Botrytis* spp. overwinter in infected canes, leaves, mummified fruit and canes on the ground. Spores are spread primarily by wind, but also by water, insects and humans. The spores germinate and penetrate plant tissue using natural openings or micro-wounds.

**Symptoms**

Mycelium (fluffy mould) develops on flowers in cool and moist conditions. In dry conditions, infected berries turn brown (Figure 84) and shrivel. *Botrytis* spp. infect flower tissues causing severe blighting, resulting in no fruit formation (Figure 85).

**Management**

**Cultural and physical**

Remove infected fruit and plant material from the orchard. Each infected fruit with spores on it can infect more flowers and fruit. Raspberries should be trained to encourage air flow and row bases should be kept clean and narrow. After harvest, cool berries rapidly and use sulfur pads in stacked trays.

**Chemical**

### Table 20. Chemical treatment options for Botrytis in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Azoxystrubin</strong>&lt;br&gt;PER84970</td>
<td>11</td>
<td>1</td>
<td>Low</td>
<td>Begin applying at disease onset. Use a maximum of three applications per season. Do not apply more than two consecutive applications with a retreatment interval of 14 days.</td>
</tr>
<tr>
<td><strong>Boscalid + pyroclostrobin</strong>&lt;br&gt;(Pristine®) PER82986</td>
<td>7, 11</td>
<td>1</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td><strong>Captan</strong>&lt;br&gt;PER13958</td>
<td>M4</td>
<td>1 (raspberries)&lt;br&gt;14 (blackberries)</td>
<td>Low</td>
<td>First application should be after the green tip spray, then repeat every 10–14 days until the season ends. Use the shorter interval when conditions favour the disease.</td>
</tr>
<tr>
<td><strong>Chlorothalonil</strong>&lt;br&gt;PER14449</td>
<td>M5</td>
<td>Do not apply later than 28 days before harvest.</td>
<td>Low</td>
<td>Apply at early bloom, 14 days later and at veraison (onset of ripening).</td>
</tr>
<tr>
<td><strong>Cyprodnil + fludioxinil</strong>&lt;br&gt;(Switch®) PER84124</td>
<td>9, 12</td>
<td>7</td>
<td>Low</td>
<td>Do not exceed a maximum of four sprays per crop per season with no more than two consecutive applications with a 7–14 day retreatment interval.</td>
</tr>
<tr>
<td><strong>Fenhexamid</strong>&lt;br&gt;PER14424</td>
<td>17</td>
<td>1</td>
<td>Low</td>
<td>Apply at first signs of infection or at white bud. Do not exceed four applications per crop per season with no more than two applications sequentially before using a fungicide from a different chemical group.</td>
</tr>
<tr>
<td><strong>Ipodione</strong>&lt;br&gt;(raspberries only)</td>
<td>2</td>
<td>1</td>
<td>Low</td>
<td>Spray at 10% blossom and full bloom. For fruit protection, apply at 14–21 days pre-harvest.</td>
</tr>
<tr>
<td><strong>Mancozeb</strong>&lt;br&gt;PER13958</td>
<td>M3</td>
<td>7</td>
<td>Medium</td>
<td>Apply at early bloom, repeat at 10–14-day intervals.</td>
</tr>
<tr>
<td><strong>Pyrimethanil</strong>&lt;br&gt;(Scala®)&lt;br&gt;PER13958</td>
<td>9</td>
<td>1</td>
<td>Low</td>
<td>Do not apply more than 2 L product per ha (400 g/L pyrimethanil product) or 1.25 L/ha (600 g/L pyrimethanil product).</td>
</tr>
</tbody>
</table>

**Figure 84. *Botrytis cinerea* infection on a raspberry.**<br>Photo: Rosalie Daniel.

**Figure 85. Spores and mycelium of *Botrytis cinerea* seen as grey fluffy growth on the fruit surface.**<br>Photo: Rosalie Daniel.
Downy mildew

Cause
Downy mildew, caused by the *Peronospora* oomycete species, overwinters inside roots, crowns and canes.

Downy mildew favours warm, humid areas and is most prevalent during wet weather with temperatures between 18–22 °C. Fungal spores can be carried by insects, wind, rain, people and equipment.

Symptoms
Symptoms appear as light green to yellow discolouration on the upper leaf surface that progresses to red and purple (Figure 86). Lesions are usually angular and restricted by veins. On the underside of the leaf, light pink to tan areas appear directly below the blotches on the upper surface (Figure 87). Spore masses are produced only on the lower leaf surface and are initially white, but become light grey with age. Infected green fruit causes premature reddening and the berries to shrivel and harden.

Management

**Cultural and physical**
Use pathogen‑free planting stock. Ensure good airflow through the canopy to promote quick leaf drying. Prune, train and thin out primocanes (vegetative canes) early to reduce humidity in the canopy. Remove and destroy old and infected prunings to reduce inoculum build‑up.

**Chemical**
The chemical treatment options for downy mildew are outlined in Table 21.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorothalonil PER14449</td>
<td>M5</td>
<td>Do not apply later than 28 days before harvest.</td>
<td>Low</td>
<td>Apply when conditions favour disease, then repeat at 7–14-day intervals. Use shorter intervals when disease pressure is high. Do not apply more than three sprays each year.</td>
</tr>
<tr>
<td>Copper present as cupric hydroxide PER14443</td>
<td>M1</td>
<td>Not required when used as directed.</td>
<td>Low</td>
<td>Apply using an air‑blast sprayer to canes approximately 7 days after planting. Use one application only. Canes must not be bearing fruit when sprayed.</td>
</tr>
<tr>
<td>Mancozeb PER13958</td>
<td>M3</td>
<td>7</td>
<td>Medium</td>
<td>Apply at early bloom and repeat at 10–14‑day intervals.</td>
</tr>
</tbody>
</table>
Phytophthora root rot

**Cause**

*X Phytophthora rubi* and other *Phytophthora* species cause phytophthora root rot. Moisture is required for reproduction and spread. Fine feeder roots are attacked, compromising water and nutrient uptake. Phytophthora root rot develops when soil temperatures are greater than 12 °C, where there is poor drainage, water ponding, heavy soils or low levels of organic matter in the soil.

**Symptoms**

Symptoms mostly occur during dry, warm weather, often in plant clusters spread along drainage lines. Primocanes wilt and shoot tips dieback. Floricanes (fruiting canes) will have weak lateral shoots. Leaves wilt, becoming yellow or brown from the margins until the leaf dies (Figure 88). Roots will be discoloured (black to brown; Figure 89) and fine feeder roots will be missing. Affected plants are easily pulled from the soil. If cut open, the centre of the main root will be brown.

**Management**

**Cultural and physical**

Always use clean, disease-free planting material. Destroy infected plants and prevent soil or water moving from infected to clean areas. Avoid soil compaction e.g. do not move soil or vehicles when it is wet. Phytophthora is suppressed in conditions of low soil compaction, high levels of organic matter and good biological action.

**Chemical**

**Table 22. Chemical treatment options for phytophthora root rot in raspberries and blackberries.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metalaxyl (Ridomil®) PER13958</td>
<td>4</td>
<td>48</td>
<td>Low</td>
<td>Apply directly to the soil and water in.</td>
</tr>
<tr>
<td>Metham PER82024</td>
<td>NA</td>
<td>Not required when used as directed.</td>
<td>Low</td>
<td>Controls germinating weed seeds and soilborne pathogens as per APVMA approved label. For pre-planting:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• plant 14–21 days after applying if soil is light–medium texture and not excessively wet or cold.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• plant a minimum of 30 days after applying if soil texture is heavy, high in organic matter, wet, or soil temperature is &lt; 15 °C.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• plant a minimum of 60 days after applying if the rate is &gt; 1,100 L/ha.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• cultivate on wet, heavy soils to prevent crustung and promote drying, 5–7 days after applying.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• sow an indicator crop (e.g. lettuce or radish) approximately 7 days before the main crop to ensure no metham remains in the soil.</td>
</tr>
<tr>
<td>Phosphonic acid (Agrifos®, Phosphon®) PER13958</td>
<td>33</td>
<td>Not required when used as directed.</td>
<td>Low</td>
<td>Apply a maximum of three applications as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rubus single crop/spring cultivars</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• when primocanes are 200–300 mm high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• 7 days before first flower</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rubus dual crop and autumn cropping cultivars</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• when primocanes are 200–300 mm high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• 7 days before first flower</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• immediately when autumn harvest terminates.</td>
</tr>
</tbody>
</table>
**Powdery mildew**

**Cause**
Powdery mildew on raspberries is caused by *Podosphaera aphanis*. This fungus overwinters in the dormant buds on stunted cane tips. Infections start on dry leaves in high humidity with temperatures over 15 °C.

**Optimum conditions include over 97% humidity and temperatures between 18–25 °C. Visible signs appear 28 days after infection. Spores are spread by wind.**

**Symptoms**
Infected raspberry and blackberry leaves initially develop light green (chlorotic) patches on the upper surface. Leaves and shoots are later covered with white to grey fungal growth (Figure 90).

Figure 90. Raspberry leaves infected with powdery mildew. Photo: M. Grabowski, University of Minnesota Extension.

**Management**

**Cultural and physical**
Remove late-forming infected primocanes and ensure good airflow through the canopy. Prune, train and thin out primocanes early to reduce humidity in the canopy. Manage nutrition and irrigation to avoid highly vigorous canopies and remove late forming infected primocanes. Use tip pruning to remove infection sources before next season. Raspberries and blackberries should be monitored when conditions favour the disease.

**Chemical**
Chemical options for controlling powdery mildew in raspberries and blackberries are outlined in Table 23.

Table 23. Chemical treatment options for powdery mildew in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boscalid + pyroclostrobin (Pristine®) PER82986</td>
<td>7, 11</td>
<td>1</td>
<td>Low</td>
<td>Apply a maximum of three foliar sprays within an annual production cycle. Do not apply more than two consecutive applications before using a fungicide from another MOA group for two applications.</td>
</tr>
<tr>
<td>Mancozeb PER13958</td>
<td>M3</td>
<td>7</td>
<td>Medium</td>
<td>Apply at early bloom and repeat at 10–14-day intervals.</td>
</tr>
<tr>
<td>Triadimenol (Bayfidan®) PER13958</td>
<td>3</td>
<td>7</td>
<td>Low</td>
<td>Apply at the first sign of disease or as a preventative treatment starting after green tip. Repeat at 10–14-day intervals whilst conditions favour the disease.</td>
</tr>
</tbody>
</table>
Spur blight

Cause
Spur blight is caused by *Didymella applanata*, a fungus which survives in lesions on diseased canes. During wet and windy periods, spores are released and carried by wind and splashing rain to nearby primocanes.

Symptoms
Symptoms first appear on young primocanes as purple–brown areas below the leaf or bud and usually on the lower portion of the stem. As the disease progresses, the lesions expand and the bark in the affected area splits lengthwise. Small black specks appear in the lesions (Figure 91).

Management

**Cultural and physical**
Control relies on improving air circulation within a planting to allow faster drying of foliage and canes. Plants should be maintained in narrow rows and thinned to improve air circulation and allow better light penetration. Excessive applications of fertiliser (especially nitrogen) should be avoided as it promotes excessive growth of susceptible succulent plant tissue. Weeds are very effective in reducing air movement; therefore, good weed control within and between rows is important for improving air circulation within the planting.

**Chemical**

Table 24. Chemical treatment option for spur blight in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper present as oxychloride</td>
<td>M1</td>
<td>1</td>
<td>Low</td>
<td>Apply just before blossoming, at petal fall and after harvest.</td>
</tr>
</tbody>
</table>
### Yellow rust

#### Cause
Yellow rust is caused by the fungus *Phragmidium rubi-idaei*, which overwinters on the bark of remaining floricanes. These are then the source of inoculum that affects emerging leaves and primocanes the following season. *P. rubi-idaei* can defoliate canes when prolonged wet weather in spring encourages rapid development.

#### Symptoms
The initial symptoms appear as raised yellow–orange pustules on the upper side of raspberry leaves (Figure 92). Later in the season, orange–yellow spots appear on the underside of leaves (Figure 93). These turn black as the fungus life cycle progresses.

#### Management
Check plants weekly from early spring for pinhead-size yellow raised spots on leaf tops. Look on the underside for yellow rust spots, particularly where there is old leaf debris.

#### Cultural and physical
Manage primocane density to maintain an open canopy to increase airflow and reduce humidity. Keep ground cover low to reduce humidity around canes.

#### Chemical
Table 25. Chemical treatment options for yellow rust in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boscalid + pyroclostrobin (Pristine®) PER82986</td>
<td>7, 11</td>
<td>1</td>
<td>Low</td>
<td>Apply a maximum of three foliar sprays within an annual production cycle. Do not apply more than two consecutive applications before using a fungicide from another mode of action (MOA) group for two applications.</td>
</tr>
<tr>
<td>Chlorothalonil PER14449</td>
<td>MS</td>
<td>Do not apply later than 28 days before harvest.</td>
<td>Low</td>
<td>Do not apply more than three sprays per year.</td>
</tr>
<tr>
<td>Copper as cupric hydroxide PER14443</td>
<td>M1</td>
<td>Not required when used as directed.</td>
<td>Low</td>
<td>Apply to canes approximately 7 days after planting. Use one application only. Canes must not be bearing fruit at the time of application.</td>
</tr>
<tr>
<td>Copper as oxychloride PER13958</td>
<td>M1</td>
<td>1</td>
<td>Low</td>
<td>Apply at bud movement.</td>
</tr>
<tr>
<td>Mancozeb PER13958</td>
<td>M3</td>
<td>7</td>
<td>Medium</td>
<td>Apply at early bloom and repeat at 10–14-day intervals.</td>
</tr>
</tbody>
</table>
Managing raspberry and blackberry pests

*Carpophilus* beetle

**Identification**
*Carpophilus* beetles are small (2–3 mm long), black or brown with a narrow, fattened oval shape (Figure 94). Their wing covers are short and do not cover the last two to three segments of the abdomen. Larvae are yellowish, about 5 mm long when fully grown, with a brown head and forked tail.

![Figure 94. Adult *Carpophilus* beetle.](image)

**Damage**
*Carpophilus* beetles feed on ripe and decomposing fruit. Adults are mechanical carriers of brown rot and Botrytis, transmitting spores as they move across the fruit, which develops at the sites of beetle damage on fruit.

![Figure 95. *Carpophilus* traps can be used for monitoring and mass trapping. Photo: bugsforbugs.com.au.](image)

**Management**

**Cultural and physical**
Improve orchard hygiene by removing and destroying waste fruit from orchards. Monitor with pheromone traps (Figure 95), placing them upwind on outside edges of the orchard for maximum pheromone spread.
Green vegetable bug

**Pest identification**
The adult green vegetable bug (GVB; *Nezara viridula*) is 15 mm long, green and shield-shaped (Figure 96). It releases a strong aroma when disturbed to deter predators. The nymphal stages look similar to the adult, but with a range of green, yellow and black markings.

The adults overwinter on other hosts (e.g. corn crops), under tree bark or in farm sheds. In warmer coastal areas, GVB will feed and breed all year round.

**Damage**
The bugs invade crops at flowering, laying eggs underneath leaves in rafts. Nymphs and adults feed by piercing flower buds and fruitlets.

**Management**

* Cultural and physical*
Remove weeds from around the crop, as many (i.e. turnip weed, wild radish and variegated thistle) are breeding hosts for the GVB.

* Biological*
Green vegetable bug eggs are parasitised by the wasp *Trissolcus basalis* (Figure 97). Parasitised eggs are easily recognised as they turn black. Nymphs are attacked by ants, spiders and predatory bugs. The final instar and adult are parasitised by the tachinid fly (*Trichopoda gicomellii*).

* Chemical*
Chemical treatment for green vegetable bugs is listed in Table 26.

---

**Damage**
The bugs invade crops at flowering, laying eggs underneath leaves in rafts. Nymphs and adults feed by piercing flower buds and fruitlets.

**Management**

* Cultural and physical*
Remove weeds from around the crop, as many (i.e. turnip weed, wild radish and variegated thistle) are breeding hosts for the GVB.

* Biological*
Green vegetable bug eggs are parasitised by the wasp *Trissolcus basalis* (Figure 97). Parasitised eggs are easily recognised as they turn black. Nymphs are attacked by ants, spiders and predatory bugs. The final instar and adult are parasitised by the tachinid fly (*Trichopoda gicomellii*).

* Chemical*
Chemical treatment for green vegetable bugs is listed in Table 26.

---

**Table 26. Chemical treatment of green vegetable bug in raspberries and blackberries.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrethrin PER80070</td>
<td>3A</td>
<td>Not required when used as directed</td>
<td>Medium</td>
<td>Early pest detection is important for good control. Monitor for eggs and egg hatching. Apply first spray at about 50% egg hatching (when the pest is at first instar). Apply a follow-up spray at 100% egg hatch.</td>
</tr>
</tbody>
</table>
Green stink bug

Pest identification
Adult green stink bugs (*Plautia affinis*) are approximately 8 mm long and have a green shield-shaped body with brown wing covers (Figure 98). Each female lays about 200–300 eggs in small loose rafts (average of 30 eggs each raft) on raspberry leaves. Nymphs hatch and pass through five instars before becoming adults. Nymphs are cream and yellow with prominent dark markings (Figure 99).

Damage
Both nymphs and adults pierce plants with needle-like mouthparts, sucking sap from buds and blossoms. Adults and nymphs also feed directly on the green, ripening and ripe raspberries causing discolouration and reduced firmness.

Management

*Biological*
Spiders, ants and predatory bugs (e.g. lacewing larva) are green stink bug predators, particularly of eggs and young nymphs. Eggs can be parasitised by the wasps *Trissolcus basalis*, *T. oenone* and *Telenomus cyrus*.

*Chemical*
The chemical treatment options for green stink bugs are outlined in Table 27.

Table 27. Chemical treatment options for green stink bugs in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrethrin PER80070</td>
<td>3A</td>
<td>Not required when used as directed.</td>
<td>Medium</td>
<td>Early pest detection is important for good control. Monitor for eggs and egg hatching. Apply first spray at about 50% egg hatching (when the pest is at first instar). Apply a follow-up spray at 100% egg hatch.</td>
</tr>
</tbody>
</table>

Figure 98. Adult green stink bug. Photo: M. Rocchetti, Costa Berries.

Figure 99. Green stink bug nymph. Photo: A. Haro, Costa Berries.
Lepidoptera

Pest identification
Many lepidoptera species e.g. loopers and Helicoverpa, can damage raspberries and blackberries. The Helicoverpa caterpillar can be up to 50 mm long and is initially pale green, sometimes with black dots and a pattern of thin dark lines running along the body (Figure 100). Looper caterpillars are green and move with a distinctive looping action (Figure 101).

Damage
Lepidoptera larvae cause the most damage. After hatching, they crawl around the plant feeding, particularly on tender tissues such as plant tips, flowers and fruit (Figure 100).

Management

Biological
Predators and parasitoids such as predatory shield bugs, tachinid fly, green lacewings (Mallada signata), brown lacewings (Micromus tasmaniae; Figure 102), damsel bugs (Nabi kinsbergii) and Trichogramma pretiosum. Bacillus thuringiensis (Bt) is a bacterium that affects the caterpillar stage of lepidoptera insects.

Chemical
Monitor for moths with pheromone traps. This gives an early warning of the arrival or emergence of the pest. It also indicates the pest pressure to be expected throughout the season. This information should be used to improve pest management decisions. The chemical treatment options for lepidoptera are outlined in Table 28.

Table 28. Chemical treatment options for lepidoptera in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus thuringiensis (Bt) (DiPel®)</td>
<td>11</td>
<td>Nil</td>
<td>Low</td>
<td>Bt must be ingested by the target insect. Therefore, thorough coverage is essential.</td>
</tr>
<tr>
<td>Helicoverpa biocontrol (nuclear polyhedrosis virus of Helicoverpa armigera)</td>
<td>NA</td>
<td>Not required when used as directed.</td>
<td>Low</td>
<td>Use a higher rate when flowers or fruit are present, under high pest pressure conditions or to control larvae larger than 7 mm long.</td>
</tr>
<tr>
<td>Carbaryl (raspberries only)</td>
<td>1A</td>
<td>7</td>
<td>High</td>
<td>Apply at first sign of pests and repeat as required. Do not spray when bees are active.</td>
</tr>
<tr>
<td>Spinetoram</td>
<td>5</td>
<td>1</td>
<td>Medium</td>
<td>Target sprays against mature eggs and newly hatched larvae when numbers exceed thresholds.</td>
</tr>
</tbody>
</table>
Mirids (green, brown and crop)

Pest identification
Green mirids (*Creonitades dilutes*), brown mirids (*Creontiades pacificus*) and crop mirids (*Sidnia kinbergi*) are known to infest raspberries (Figure 103). Mirids overwinter in low numbers, then as temperatures begin to rise in August, populations increase.

Green mirid adults are 7 mm long, pale green often with red markings and have clear wings that fold flat on their back (Figure 104).

Brown mirids are similar in shape, but the adults can be slightly larger and their front is brown instead of green when viewed from above.

Crop mirids are grey–green on top and bright green underneath.

Damage
Both adults and nymphs pierce plant tissue and release a chemical that destroys cells in the feeding zone. They damage buds, flowers and growing points through feeding. This results in reduced berry weight and increased fruit distortion (Figure 105).

Management
Cultural and physical
Remove or control weeds surrounding crops. There is potential to use Lucerne as a trap crop for mirids where appropriate.

Biological
A number of beneficial species are known to feed on mirids. Adults, nymphs and eggs are eaten by damsel bug, big-eyed bug, predatory shield bugs (Figure 106), and a number of spider species.

Figure 103. A green mirid on a raspberry. Photo: Emma Nightingale, Costa Berries.

Figure 104. A green mirid.

Figure 105. A distorted raspberry from mirid damage. Photo: Emma Nightingale, Costa Berries.

Figure 106. The spined predatory shield bug is a biological control option for mirids. Photo: Lynn Bunting.
Mites

Pest identification

Broad mite

Broad mites (*Polyphagotarsonemus latus*) are tiny (less than 0.2 mm) and difficult to see even with a 16x hand lens. They differ from other mites in that they feed on the upper surface of plant tissue rather than on the underside.

Red berry mite

Red berry mites (*Acalitus essigi*) are microscopic, white-ish mites that sucks sap from blackberry flowers and fruit. Red berry mites overwinter under bud scales and become active on the foliage during spring. At flowering, the mites move onto the flowers and developing fruits.

Two-spotted mite

The two-spotted spider mite (*Tetranychus urticae*) is most commonly found in red raspberries. Numbers increase during warm weather. Two-spotted mites are about 0.05 cm long and vary in colour from light yellow or orange to green or even black. Both males and females usually have two large spots on each side of the body (Figure 107).

Damage

Broad mite

Given their very small size, signs of damage are all that are likely to be noticed. Typical damage from broad mites includes tissue distortion, reduced terminal growth, leaves withering downward or curling or cupping upward (Figure 108), flower clusters that appear compressed and blossoms that dry up (Figure 109).

Red berry mite

Red berry mites inject a toxin into the fruit during feeding. This causes some drupelets to ripen normally while others remain red and hard (Figure 110).

Two-spotted mite

Under high infestation, leaves can be marked by white stippling or bronzing after the mites have fed (Figure 111). Severe damage can reduce photosynthetic capacity and therefore yield and fruit quality.
Management

Cultural and physical

Reducing dust and ensuring adequate irrigation will help reduce mite outbreaks. Heavily affected canes can be cut to ground level and removed from the farm as soon as the problem is noticed. Canes with persistent red berry mite problems are probably best replaced.

Chemical

Chemical options for controlling mites in raspberries and blackberries are outlined in Table 29.

Table 29. Chemical treatment options for mites in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Mite species</th>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spider mite, red-legged earth mite</td>
<td>Dimethoate</td>
<td>1B</td>
<td>7</td>
<td>High</td>
<td>Some strains of spider mites are resistant to organophosphorus compounds.</td>
</tr>
<tr>
<td>Two-spotted mite</td>
<td>Abamectin PER13956</td>
<td>6</td>
<td>7</td>
<td>High</td>
<td>Do not use more than two applications per crop with a minimum retreatment interval of 28 days between consecutive applications.</td>
</tr>
<tr>
<td>Two-spotted mite, European red spider mite</td>
<td>Bifenazate PER14425</td>
<td>25</td>
<td>1</td>
<td>Medium</td>
<td>Do not apply more than two applications per crop per season, with a minimum interval of 21 days between consecutive applications.</td>
</tr>
<tr>
<td>Two-spotted mite</td>
<td>Emulsifiable botanical oil PER14234</td>
<td>NA</td>
<td>Not required when used as directed</td>
<td>Low</td>
<td>Do not apply more than three separate sprays to plants within a 4–8 week period. Do not apply in temperatures exceeding 35 °C.</td>
</tr>
<tr>
<td>Two-spotted mite</td>
<td>Petroleum oil PER13957</td>
<td>NA</td>
<td>1</td>
<td>Low</td>
<td>Spray every 5–7 days or as required using an air-blast type sprayer.</td>
</tr>
</tbody>
</table>
Queensland fruit fly

Pest identification
Adult Queensland fruit flies (QFF) are about 6–8 mm long and reddish brown with yellow markings (Figure 112). They are most active in warm, humid conditions and after rain. QFF lay eggs in maturing and ripe fruit on bushes and sometimes in fallen fruit.

Figure 112. Queensland fruit fly.

Damage
The larvae feed inside the fruit, creating internal rots and fruit-fall.

Management
A single control method is not sufficient to eradicate QFF from an area. A combination of methods, including population monitoring by trapping, area saturation with male annihilation technology (using pheromones to attract and kill males), protein bait sprays and strict orchard hygiene practices are required.

Cultural and physical
Use fruit fly traps to monitor QFF population trends (Figure 113). To improve the flow in the traps, replace the wicks every three to six months (depending on product). Start monitoring in spring and continue throughout the year until winter. Monitoring over time provides information on fly behaviour, where to focus your efforts and an assessment of your management strategies.

Orchard hygiene is essential as bushes with fallen and rotting fruit are a source of fruit fly infestations. Fruit flies can travel several hundred metres in their lifetime, so infected fruit should not be left within one kilometre of the orchard. Practice good packing shed hygiene with thorough inspections to remove any infested fruit and dispose of it appropriately.

Male annihilation technology (MAT): This is an ‘attract and kill’ strategy for male flies. The aim is to reduce male populations to low levels, thus reducing mating opportunities for females. The technique involves distributing devices containing Cue-Lure (male attractant) and an insecticide. Place the lures throughout the crop and in alternative hosts (i.e. fruiting windbreaks) at a density of about 16–20 per hectare. Additional lures should also be placed every 20 metres around the perimeter of the property early in the season (late winter) to reduce the number of male flies entering the orchard. New lures should be placed into your orchard three times a year, and each MAT device should be left in the field for 12 months. Distribute MAT cups the next season using orange in spring, yellow in summer and pink in autumn (Figure 114).

Figure 113. Fruit fly trap for monitoring QFF populations.

Figure 114. MAT cups, showing colour variants for seasonal placement. Photo: bugsforbugs.com.au.
Both male and female QFF need protein to reach sexual maturity, therefore **protein bait spraying** is an effective control method. It involves using a protein source (e.g. yeast autolysate PER13785) to attract QFFs and an insecticide (e.g. maldison or trichlorfon) to kill them. Begin spraying as soon as traps indicate QFF are present or fruit is at a susceptible stage. Apply bait sprays to the trunks of bushes or on trellis posts (Figure 115) where QFF are likely to be active. Do not spray the fruit to avoid concerns about residue and fruit damage. Repeat applications every seven days, or sooner if rain has washed off the mixture.

**Chemical**

Table 30. Chemical treatment options for Queensland fruit fly in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abamectin PER14423</td>
<td></td>
<td>6</td>
<td>7</td>
<td>High \nApply as a strip or spot treatment with yeast autolysate.</td>
</tr>
<tr>
<td>Maldison (Fyfanon® 440 EW)</td>
<td>1B</td>
<td>3</td>
<td>High</td>
<td>Apply as a strip or spot spray with yeast autolysate. For spot spraying apply 100–150 spots/ha using 50–100 mL/spot of bait solution. Apply at 7-day intervals from 42 days before harvest to 14 days after harvest.</td>
</tr>
<tr>
<td>Spinetoram PER12927</td>
<td>5</td>
<td>1</td>
<td>Medium</td>
<td>Thoroughly apply foliar cover spray after flower set depending on pest pressure as determined by regular crop scouting and fruit fly trapping. Do not use more than four applications each season, with a minimum of 7–14 days between consecutive (repeat) sprays.</td>
</tr>
<tr>
<td>Trichlorfon</td>
<td>1B</td>
<td>2</td>
<td>Medium</td>
<td>Can be used as a cover spray with a maximum of three applications each season.</td>
</tr>
</tbody>
</table>
Rutherglen bug

Pest identification
Rutherglen bugs (*Nysius vinitor*) are native insects. The adult female is 5 mm long, grey–brown with black eyes. The male is smaller and darker. Adults have two pairs of wings; the lower pair are silvery and shorter, the upper pair is darker silver with dark lines trailing the edges (Figure 116). Nymphs are reddish brown, pear-shaped and wingless (Figure 117). They range in size from 1–5 mm.

Rutherglen bugs have a wide host range, are strong fliers and migrate in swarms. They are influenced strongly by weather and are most prevalent in spring and summer during warm, dry periods and when surrounding weeds are drying off.

Damage
Rutherglen bugs cause damage by sucking sap from fruit and leaves.

Management

**Cultural and physical**
Managing weeds around the crop can reduce the likelihood of bugs moving from weeds into the crop.

**Biological**
General Rutherglen bug predators and parasites include assassin bugs, ladybirds and spiders. Egg parasitoids are the most commonly recorded Rutherglen bug natural enemy. To improve the abundance and diversity of beneficial insects, consider native vegetation as part of a pest management strategy.

**Chemical**

Table 31. Chemical treatment options for Rutherglen bug in raspberries and blackberries.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbaryl (raspberries only)</td>
<td>1A</td>
<td>7</td>
<td>High</td>
<td>Apply when pests first appear and repeat as required.</td>
</tr>
<tr>
<td>Dimethoate (QLD, VIC, TAS, SA and WA only)</td>
<td>1B</td>
<td>7</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>
Thrips

Pest identification
Thrips are small insects, ranging from 0.5–2 mm, occasionally up to 14 mm long. They are cylindrical; the head often being narrower than the prothorax or the rest of their body (Figure 118 and Figure 119). Adults can be winged or wingless. When present, both pairs of wings are slender, with long comb-like hairs.

Eggs are laid in slits made in leaves and growing points. There are two larval stages, a pre-pupal and a pupal stage. Nymphs and adults feed in growing points and inside flowers. Western flower thrips can blow into properties on hot winds, usually in October.

Damage
Thrips damage blackberry and raspberry fruit by feeding on the drupelets adjacent to the calyx, producing a speckled silver appearance.

Management
Detect thrips by shaking flowers upside down over a sheet of paper or onto one’s hand. If more than five thrips are detected in 10 flowers, then treatment is necessary. Increase the frequency of monitoring during expected periods of infestation (e.g. spring and summer), particularly during periods with strong winds.

Cultural and physical
As broadleaf weeds are alternative hosts for Western flower thrips, these should be prevented from flowering.

Biological
Neoseiulus cucumeris (Figure 120) and Typhlodromips montdorensis are predatory mites available for thrips control. Basil can be planted throughout orchards to act as a banker plant for Orius thrips predators, and as a trap plant for thrips. Use approximately 200 bankers/ha (more or less depending on thrips pressure). Lacewing larvae and ladybird beetles also prey on thrips.

Chemical

<table>
<thead>
<tr>
<th>Pest</th>
<th>Treatment</th>
<th>Insecticide group</th>
<th>WHP (days)</th>
<th>Effect on beneficials</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>All thrips</td>
<td>Dimethoate</td>
<td>1B</td>
<td>7</td>
<td>High</td>
<td>Apply when pest first appears.</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>Bifenthrin</td>
<td>PER84972</td>
<td>3A</td>
<td>1</td>
<td>High Apply at flowering when thrips numbers are sufficient to require control. Monitor thrips numbers and spray when economic damage thresholds are reached.</td>
</tr>
<tr>
<td>Western flower thrips</td>
<td>Spinetoram</td>
<td>5B</td>
<td>1</td>
<td>Medium</td>
<td>Only use three consecutive applications before switching to an approved product from another chemical group.</td>
</tr>
</tbody>
</table>

Figure 118. Plague thrips.

Figure 119. Western flower thrips. Photo: David Cappaert, Bugwood.org.

Figure 120. Neoseiulus cucumeris devouring first instar Western flower thrips. Photo: Biological Services.
Commercial producers of biological control agents for Integrated Pest Management (IPM) programs.

KEY PESTS  BIOCONTROL SOLUTION

Two Spotted Mite  Persimilis  Californicus  Occidentalis

Whitefly  Nesidiocoris  Encarsia  Eretmocerus

Diamondback Moth  Diaegma

Fungus Gnat / Thrips  Hypoaspis ‘M’  Dalotia  Hypoaspis ‘A’

Thrips  Cucumeris  Orius  Thripobius

Red Scale  Aphytis  Lindorus

Aphiids  Aphidius ‘E’  Aphelinus  Aphidius ‘C’  Transversalis  Hippodamia
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Proudly possessing a reputation for excellence in the provision of customer-centric packaging solutions, over the past 20 years Multisteps has grown to hold the majority share of Australia’s fresh food packaging market whilst simultaneously establishing a firm presence on the international stage.

Fully committed to sustainable practices, Multisteps creates 100% recyclable packaging solutions and is at the forefront of the development and implementation of innovative bioplastics that are increasingly environmentally friendly.

Working with our customers and production managers closely to develop customised packaging solutions, Multisteps delivers exceptional experiences over every step of the journey.

MOST REQUESTED...
Managing weeds

Why manage weeds?
Rapid canopy establishment and early cropping are key to profitability in an orchard block, particularly modern intensive systems. Weeds compete with bushes for moisture and nutrients and can create a microclimate that favours pests and diseases.

Research shows that competition from weeds in young, developing orchards can result in slower canopy establishment and delayed productivity. A poor weed management strategy will also have a negative effect on yields in established orchards.

An effective weed management strategy will help growers to achieve their goals for orchard establishment, early yields and hygiene.

Hygiene comes first
Good orchard hygiene is the first step in any weed management strategy. Movement of weeds on and throughout your property and the appearance of new weed species are largely determined by the degree of weed hygiene employed. Be aware of new weeds appearing on your property. Have them identified if necessary, and work towards eradicating them or reducing their spread. Moving machinery from non crop areas to the orchard and between blocks is the most likely 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, bush age, weed spectrum and density, soil type, available moisture and choice of under bush management (i.e. bare earth, mulched or sod culture). Strategies will need to respond to changes in the weed spectrum and growing conditions. Weed management methods can be grouped as either physical or chemical, or can incorporate elements of both.

Physical weed control methods

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 bushes, especially in blocks on dwarf stocks. 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 annuals or perennial weeds. There are also occupational health and safety issues and fire hazards associated with these methods. Do not use thermal weeding near bushes less than three years old as severe crop damage can occur.

Grazing
Grazing sheep, geese and fowl 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 damage bushes 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 is the most effective alternative to chemical weed control. Mulching mounds with large quantities of organic materials such as straw, old hay or wood chips, has multiple benefits including moisture retention, soil temperature regulation, and building up organic matter and soil microbes.

To be effective, mulch must be applied at a sufficient thickness to act as a physical barrier to sunlight and weed growth. This depth will depend on the type of mulch being used.
In blueberry orchards with bushes planted on mounds in rows, the mounds must be broad enough to prevent organic mulches from sliding off them. As the mulch decomposes, it will need to be renewed, possibly every few years. Growers should also be aware of the possibility of nitrogen drawdown effect when using some raw non composted mulches.

Side cast mowers deposit slashed material along the bush row, which can help to suppress weeds and build up organic matter. However, this is not effective as a stand-alone mulch treatment if the aim is to achieve a weed-free strip.

Synthetic weed mat is used for weed control in high rainfall areas. It is effective at reducing weeds on mounds, but it can lead to disease and soil health problems inside mounds. Many growers use weed mat to control weeds on the side of the mound, but have a large planting hole cut into the weed mat that is covered with organic mulch to allow planting, access to irrigation lines, fertiliser application and rainfall to penetrate.

**Chemical weed control**

**Types of herbicide and when to spray?**

Generally, the best time to spray for weeds in the orchard is either just before (pre-emergent) or just after germination (post-emergent). The majority of weeds germinate in either spring or autumn. Small weeds are easier to control than older, more mature weeds. Orchard herbicides can be grouped into three broad categories:

1. **Pre-emergent residual herbicides** (Table 33) work best when applied to bare soil that is totally weed and debris free. 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 if applied correctly.

2. **Post-emergent selective grass herbicides** (Table 34) are useful where the predominant weed species is grass. The three active ingredients with registrations for use in NSW as selective grass herbicides are all members of the Group A herbicide mode of action (MOA) group. This means they are considered highly prone to developing resistance and should be used in accordance with resistance management principles.

3. **Post-emergent non-selective knockdown herbicides** (Table 35) perform best when applied to young, actively growing broadleaf weeds and some grasses. As these herbicides are non-selective, some can be harmful to fruit bushes. Young bushes are particularly prone to injury if not protected from knockdown herbicides. Consult product labels for specific recommendations.

**Should I be concerned about herbicide resistance?**

Yes.

Ryegrass resistant to glyphosate is present in orchards across Australia because of an over reliance on Group M herbicides. Some useful tips on how to avoid resistance in your orchard can be found at [www.glyphosateresistance.org.au](http://www.glyphosateresistance.org.au).

Herbicides work by interfering with specific processes in plants. This is known as their mode of action (MOA). All herbicides have been classified into groups from A to Z according to their MOA. Some groups are more likely to develop resistance and are considered high risk. The earlier the group is in the alphabet, the higher the susceptibility to resistance. Refer to product labels to determine the MOA group.

To minimise the risk of herbicide resistance developing in your 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: for example, never use a Group A herbicide when a Group L or M herbicide will do the job
- 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 that you 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 being used
• always use a low-drift type nozzle wherever possible, e.g. 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 the section on Spray drift on page 75
• select the correct nozzle size from the manufacturer’s chart once you have decided on a safe ground speed and the recommended application volume for the herbicide being used
• ensure a ‘double overlap’ of the spray fans at the top of the target, not at ground level. Too low will result in herbicide being applied unevenly, while too high will increase the risk of off-target damage
• if an individual nozzle’s output (litres per minute) varies by more than 5% from the manufacturers’ specifications, replace those nozzles
• ensure all equipment is properly calibrated before use
• herbicide labels can include mandatory advice on droplet spectrum, e.g. medium–coarse. If so, be sure to choose the right nozzle and operating pressure.

**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 and the correct pump pressure
2. Fill the spray tank with water and note the exact level reached
3. Measure a 100 m strip and spray it with water
4. Measure the width of the sprayed strip
5. Return the rig to the exact position where it was filled the first time and measure how much water it takes to refill the tank to exactly the same level as before.

The area covered by a full tank can then be calculated using the following:

**Assume**

Length of sprayed area \([L] = 100 \text{ m}\)
Width of sprayed area \([W] = 1.5 \text{ m}\)
Tank capacity \([T] = 500 \text{ L}\)
Volume of water used in test spray \([V] = 10 \text{ L}\)
Application rate of product \([R] = 3.75 \text{ kg/ha}\)

Then

Area covered by a full tank is \(L \times W \times T \div V\)

In our example, the area covered is:

\[100 \text{ m} \times 1.5 \text{ m} \times 500 \text{ L} \div 10 \text{ L} = 7,500 \text{ m}^2 \text{ or } 0.75 \text{ ha}\]

(there are 10,000 m² per hectare)

**So the herbicide required in a full tank**

= application rate \([R]\) × area covered by a full tank.

In our example the amount of herbicide required

\(= 3.75 \text{ kg/ha} \times 0.75 \text{ ha} = 2.8 \text{ kg}\).
### Herbicides and their uses

**Table 33. Pre-emergent residual herbicides for blueberry, raspberry and blackberry orchards.**

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Example trade name</th>
<th>Herbicide group</th>
<th>Crop</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichlobenil (TAS only)</td>
<td>Casoron® 4G</td>
<td>O</td>
<td>Raspberries</td>
<td>Not required when used as directed.</td>
<td>Annual grasses and broadleaf weeds.</td>
<td>Apply late winter to early spring before growth has started.</td>
</tr>
<tr>
<td>Dichlobenil (Permit PER12219 expires March 2022)</td>
<td>Casoron® 4G</td>
<td>O</td>
<td>Blueberries</td>
<td>Not required when used as directed.</td>
<td>Annual grasses and broadleaf weeds.</td>
<td>Do not apply more than two applications per year.</td>
</tr>
<tr>
<td>Metham (Permit PER82024 expires March 2021)</td>
<td>Metham NA</td>
<td>NA</td>
<td>Blueberries, Raspberries, Blackberries</td>
<td>Not required when used as directed.</td>
<td>Germinating weed seeds.</td>
<td>Refer to APVMA approved label [34049/57948] for TRICKLE IRRIGATION: Field application to bed or rows.</td>
</tr>
<tr>
<td>Oryzalin (non-bearing plants only)</td>
<td>Stonewall® D</td>
<td>O</td>
<td>Blueberries, Raspberries, Blackberries</td>
<td>Not required when used as directed.</td>
<td>Certain annual grasses and broadleaf weeds.</td>
<td>Activated by moisture. For use on non-bearing bushes only.</td>
</tr>
<tr>
<td>Simazine</td>
<td>Gesatop® C</td>
<td>C</td>
<td>Raspberries</td>
<td>Not required when used as directed.</td>
<td>A range of broadleaf weeds.</td>
<td>Do not apply to foliage or when fruit is present. Use on established plants only.</td>
</tr>
</tbody>
</table>

**Table 34. Post-emergent selective grass herbicides for blueberry, raspberry and blackberry orchards.**

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Example trade name</th>
<th>Herbicide group</th>
<th>Crop</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluazifop-P (Permit PER86586 expires August 2023)</td>
<td>Fusilade Forte® A</td>
<td>A</td>
<td>Blueberries</td>
<td>28 days.</td>
<td>Barnyard grass, crowfoot grass, stink grass, Urochloa grass, carpet grass, couch grass, Johnson grass, kikuyu and paspalum.</td>
<td>Use higher water volumes if weeds are dense.</td>
</tr>
<tr>
<td>Haloxyfop</td>
<td>Imtrade Haloxyfop 900 EC® A</td>
<td>A</td>
<td>Blueberries</td>
<td>Not required when used as directed.</td>
<td>Annual and perennial grasses.</td>
<td>Spray should be directed to the base of the bush to avoid contact with fruit and foliage.</td>
</tr>
</tbody>
</table>
Table 35. Post-emergent non-selective knockdown herbicides for blueberry, raspberry and blackberry orchards.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Example trade name</th>
<th>Herbicide group</th>
<th>Crop</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glufosinate-ammonium (Permit PER81429 Expires 30 June 2019)</td>
<td>Basta®</td>
<td>N</td>
<td>Blueberries</td>
<td>Not required when used as directed.</td>
<td>A broad-spectrum herbicide that controls a wide range of grasses and broadleaf weeds.</td>
<td>Do not apply in unfavourable weather conditions. Do not apply to young, green or uncalloused and damaged blueberry plants.</td>
</tr>
<tr>
<td>Glufosinate-ammonium (NSW, VIC and TAS only)</td>
<td>Basta®</td>
<td>N</td>
<td>Raspberries and Blackberries</td>
<td>Not required when used as directed.</td>
<td>Primocane and sucker control.</td>
<td>Contact with flowers, developing fruit or desirable foliage will cause damage.</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Roundup®</td>
<td>M</td>
<td>Blueberries and Raspberries</td>
<td>Not required when used as directed.</td>
<td>Controls a wide range of annual and perennial weeds.</td>
<td>Do not allow spray or spray drift to contact green bark, fresh wounds, foliage or fruit. Do not use near bushes less than three years old unless they are properly protected from spray drift.</td>
</tr>
<tr>
<td>Paraquat</td>
<td>Inferno</td>
<td>L</td>
<td>Blueberries</td>
<td>Not required when used as directed</td>
<td>Most annual grasses and some broadleaf weeds.</td>
<td>Avoid spray drift onto plant parts with green pigment. Spray only actively growing weeds (5–10 cm high).</td>
</tr>
</tbody>
</table>
Managing your legal responsibilities when applying pesticides

The Pesticides Act

The Pesticides Act 1999, administered by the Environment Protection Authority (EPA), is the primary legislative instrument controlling pesticide use in NSW. The underlying principle of the Pesticides Act is that pesticides must only be used for the purpose described on the product label and all the instructions on the label must be followed. Consequently, all label directions must be read by, or explained to, the user before using the pesticide.

All pesticide users should take reasonable care to protect the health of themselves and others when using a pesticide. This includes preventing damage occurring from using a pesticide, such as off-target drift onto sensitive areas, or harm to endangered and protected species.

A Regulation was gazetted in 2017 renewing the requirement for all commercial pesticide users to keep records of their pesticide application. Records must be made within 24 hours of application, in legible English, and kept for three years. While no set form has to be used, records must include the following:

- full product name
- description of the crop or situation
- application rate and quantity applied
- description of the equipment used
- address of the property, identification of the area and order of paddocks treated
- date and time of the application (both start and finish)
- name, address and contact details of the applicator and the employer (or owner if an employee or contractor is the applicator)
- estimated wind speed and direction (including any significant changes during spraying)
- other weather conditions specified on the label as being relevant (e.g. temperature, rainfall, relative humidity).

An example spray record form from SMARTtrain is provided in Table 36.

The SMARTtrain spray record book is available from NSW DPI ($10.00). Call 1800 138 351 or visit www.smarttrain.com.au/resources to order your copy. More information on spray record responsibilities is available on the Environment Protection Authority website (www.epa.nsw.gov.au/pesticides/pestrecords.htm). The EPA also has a spray record form (www.epa.nsw.gov.au/resources/pesticides/130814PestFmEg.pdf) you can download and use. These forms can be used for livestock, vertebrate pests, crops and pastures. Sequentially numbered forms are required for those producers in Quality Assurance (QA) schemes.

The 2017 Regulation requires all commercial pesticide users to be trained in applying pesticides. Trained aerial applicators, pest control operators and fumigators satisfy the requirements of the Regulation. Other commercial users must have a prescribed qualification. Only domestic use, such as home gardens, is excluded, provided the pesticide is a specific domestic/home garden product.

Covered by the Regulation is pest control by or on:

- public authorities, e.g. State Rail
- golf courses, sporting fields, bowling greens
- agricultural, horticultural, aquacultural and forestry operations
- businesses, educational institutions and hospitals.

The minimum prescribed training qualification is the AQF2 unit of competency, ‘Apply chemicals under supervision’, although owner-applicators are encouraged to train and be assessed in the two higher AQF3 competencies, ‘Prepare and apply chemicals’ and ‘Transport, handle and store chemicals’.

Growers should do the SMARTtrain course Chemical Application, or the standard ChemCert course, both of which cover the higher AQF3 competencies. For growers with literacy and/or numeracy problems, the lower level AQF2 competency will provide a minimum qualification that satisfies the Regulation.
Table 36. An example spray record form.

<table>
<thead>
<tr>
<th>Chemical application record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property address:</td>
</tr>
<tr>
<td>Owner:</td>
</tr>
<tr>
<td>Person applying chemical:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spray application area</th>
<th>Situation of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray map including sensitive areas, wind direction, order of treatment</td>
<td>Area sprayed and order of spraying</td>
</tr>
<tr>
<td>Block name/ number</td>
<td>Area (ha)</td>
</tr>
<tr>
<td>Pest(s)</td>
<td>Pest growth stage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GPS reference: S E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application equipment</td>
</tr>
<tr>
<td>Equipment type</td>
</tr>
<tr>
<td>Water quality (eg. pH, hardness)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No-spray zone (metres):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment type</td>
</tr>
<tr>
<td>Water quality (eg. pH, hardness)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full product name (including additives)</td>
</tr>
<tr>
<td>Full product name (including additives)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weather details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (amount and time from spraying) Before: mm During: mm After: mm</td>
</tr>
<tr>
<td>Time of spraying: Start:</td>
</tr>
<tr>
<td>Start:</td>
</tr>
<tr>
<td>Start:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clean up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal of rinsate:</td>
</tr>
</tbody>
</table>

Source: Adapted from SMARTtrain Chemical Accreditation Program Calibration and Records Supplement.
Hazardous chemicals legislation
Many registered pesticides are classified as hazardous chemicals. The Work Health and Safety Act 2011 and the Hazardous Chemical section of the Work Health and Safety Regulation 2017 detail the legal requirements for managing hazardous chemicals for suppliers, workers and persons conducting businesses or undertakings. The Act and Regulation are intended to protect workers from both the short- and long-term health effects of exposure to hazardous chemicals and to improve current health and safety practices by:

- providing health and safety information to workers (including a list of all hazardous chemicals and an SDS (Safety Data Sheet) for each hazardous chemical)
- consulting with workers
- training workers
- minimising the risks from exposure to hazardous chemicals
- health surveillance (if warranted by the risk assessment in respect of organophosphates).

Storage limits have changed. Premises storing large quantities require both the storage shed and the entrances to the premises to have placards. If very large quantities are stored (which would be rare on farm), a manifest, site plan and written emergency plan are required.

SafeWork NSW's Code of practice for the safe use and storage of chemicals explains the specific quantities of the various chemicals.

SafeWork NSW's Code of practice for the safe use and storage of chemicals (including pesticides and herbicides) in agriculture is an approved industry code of practice and provides practical guidance for farm chemical users to comply with the legislation.

Pesticides and worker safety
Most registered pesticides pose some health risk to those who use them or are exposed to them. Pesticides can have both immediate (acute) and long term (chronic) effects.

Acute toxicity
The acute or immediate toxicity of a farm chemical is reflected in the Poisons Schedule or poison warnings that appear on the pesticide label. The acute toxicity is assessed by the potential of the active ingredient to poison an individual by the route of exposure that is most lethal, e.g. oral ingestion.

Poisons Schedule
Pesticides are classified into categories based on their acute health hazard to the user. Each schedule has a corresponding signal heading that appears in large, contrasting lettering on the pesticide product label.

The Poisons Schedule (Table 37) will largely determine the Safety Directions and First Aid Instructions that appear on the label. The Safety Directions specify the personal protective equipment (PPE) to be worn and the safety precautions to be taken, e.g. ‘do not inhale spray mist’. The First Aid Instructions specify what to do if a poisoning occurs. Safety Directions and First Aid Instructions can vary for different formulations of the same pesticides.

Note: Before opening and using any farm chemical, consult the label and the Safety Data Sheet (SDS) for specific safety directions. The Hazardous Substances Section of the Work Health and Safety Act 2011 requires resellers to provide end users with an SDS.

If you suspect a poisoning, contact the Poisons Information Centre on 131 126 (24 hours).

Anticholinesterase compounds
Insecticides are generally more acutely toxic than herbicides or fungicides. This is because most insecticides act on the central nervous system (CNS). Organophosphates (OPs) are the most acutely toxic insecticides because they depress cholinesterase enzyme action in the CNS. The carbamate group of insecticides also depresses cholinesterase, but the health effects are less severe because the enzyme regenerates rapidly by itself following carbamate exposure. Nevertheless, carbamates (such as aldicarb) have extremely high acute toxicity and are capable of causing severe illness and death.

Products that depress cholinesterase are especially hazardous, not only because of their effect on the CNS, but because they are readily absorbed through the skin. These products must be identified by the words ‘an anticholinesterase compound’ underneath the name of the active ingredient on the product label.

The Safety Directions on the label will include advice on safe work practices and the PPE specific to anticholinesterase products. Where work practices and application technology create a high risk of exposure to anticholinesterase compounds, it might be necessary to monitor
the health of those who are exposed. Additional details on biological monitoring and health surveillance is included in the Code of practice for the safe use and storage of chemicals (including pesticides and herbicides) published by SafeWork NSW.

**Solvents and distillates**

In addition to the active ingredient, pesticide formulations contain surfactants and carriers that can also be toxic. Many liquid pesticide formulations are based upon petroleum distillates (e.g. xylene) or organic solvents. These are corrosive to the skin and eyes, and if inhaled, their vapours can affect the brain. The exposure risk with these is highest when handling the concentrate, which is why pesticide labels often carry warnings to avoid inhaling the vapours and splashing the skin and eyes.

**Routes of exposure**

The most hazardous route of exposure for insecticides is dermal absorption (through the skin) and the most hazardous phase of application is mixing and loading the concentrated product. Excepting fumigants, the inhalation risk for most pesticides and application technology is low. Nevertheless, a respirator might be required when mixing, loading or applying pesticides:

- in an enclosed space (such as a shed)
- if the pesticide is highly volatile and likely to be breathed in as a vapour (such as 2,4-D ester)
- if application carries the risk of inhaling the spray mist (such as having to turn back into the drift in crops with short rows).

Ingestion is a risk for applicators who do not wash their hands before eating and drinking, or who smoke during application. Unsecured storage is high risk to children who could accidentally ingest a pesticide.

Many pesticide formulations can have direct or topical effects on the skin and eyes. These effects are often unrelated to whether or not the chemical is acutely toxic. Some pesticides might have low acute toxicity but severe topical effects. For example, glyphosate has very low acute toxicity but is irritating to the skin and eyes. Warnings regarding skin and eye irritation and other topical effects are usually found on the product label under ‘Safety Directions’.

Table 37. The Poisons schedule.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule 1</td>
<td>This Schedule is intentionally blank.</td>
</tr>
<tr>
<td>Schedule 2</td>
<td>Pharmacy Medicine – substances, the safe use of which may require advice from a pharmacist and which should be available from a pharmacy or, where a pharmacy service is not available, from a licensed person.</td>
</tr>
<tr>
<td>Schedule 3</td>
<td>Pharmacist Only Medicine – substances, the safe use of which requires professional advice but which should be available to the public from a pharmacist without a prescription.</td>
</tr>
<tr>
<td>Schedule 4</td>
<td>Prescription Only Medicine or Prescription Animal Remedy – substances, the use or supply of which should be by or on the order of persons permitted by State or Territory legislation to prescribe and should be available from a pharmacist on prescription.</td>
</tr>
<tr>
<td>Schedule 5</td>
<td>Caution – substances with a low potential for causing harm, the extent of which can be reduced through the use of appropriate packaging with simple warnings and safety directions on the label.</td>
</tr>
<tr>
<td>Schedule 6</td>
<td>Poison – substances with a moderate potential for causing harm, the extent of which can be reduced through the use of distinctive packaging with strong warnings and safety directions on the label.</td>
</tr>
<tr>
<td>Schedule 7</td>
<td>Dangerous Poison – substances with a high potential for causing harm at low exposure and which require special precautions during manufacture, handling or use. These poisons should be available only to specialised or authorised users who have the skills necessary to handle them safely. Special regulations restricting their availability, possession, storage or use may apply.</td>
</tr>
<tr>
<td>Schedule 8</td>
<td>Controlled Drug – substances which should be available for use but require restriction of manufacture, supply, distribution, possession and use to reduce abuse, misuse and physical or psychological dependence.</td>
</tr>
<tr>
<td>Schedule 9</td>
<td>Prohibited Substance – substances which may be abused or misused, the manufacture, possession, sale or use of which should be prohibited by law except when required for medical or scientific research, or for analytical, teaching or training purposes with approval of Commonwealth and/or State or Territory Health Authorities.</td>
</tr>
<tr>
<td>Schedule 10</td>
<td>Substances of such danger to health as to warrant prohibition of sale, supply and use – substances which are prohibited for the purpose or purposes listed for each poison.</td>
</tr>
</tbody>
</table>

**Re-entry intervals**
The re-entry interval is the time that must elapse between applying the pesticide and re-entry into the sprayed crop, unless the person is wearing the PPE specified for re-entry on the label.

Re-entry intervals are needed because pesticides sometimes remain on crops in the form of foliar aerosol particles. These residues can be dislodged by contact with the crop and absorbed through the skin by those working in the crop.

Re-entry intervals only appear on the label of a small number of pesticide products. If a re-entry period is not specified on the label, the rule of thumb is to wait 24 hours after application or until the crop is dry, whichever is longer. Crops should never be re-entered when wet from dew or light rain, irrespective of the time elapsed, unless appropriate PPE is worn.

**Chronic toxicity**
The effects of long-term exposure to small doses of chemical are known as chronic toxicity. Some of these effects include:

**Neurotoxic effects**
Organophosphate pesticides are suspected of having long-term effects on the CNS. To date, these effects are slight and have only been detected in a tiny proportion of those exposed. It is important to note that all effects, both acute and chronic, are dose-related. This means that adherence to label directions to control acute exposure will similarly control chronic exposure.

**Reproductive effects**
Some pesticides are suspected of being foetotoxic (fatal to foetuses) and teratogenic (causing birth defects) based on laboratory studies involving animals. However, there is little evidence that pesticides can affect human reproduction or the health of the unborn foetus at the levels of pesticide exposure that most of the population experiences through their food supply.

The Australian College of Occupational Medicine recommends that women who are pregnant or likely to become pregnant protect themselves against chemical exposures that can have adverse reproductive effects. Pregnant women should not be involved in spraying agricultural chemicals or working in recently sprayed crops. Advice on pregnancy and occupational exposure to pesticides is available from medical practitioners accredited by SafeWork NSW in occupational health.

**Cancer and pesticides**
Despite widespread public suspicion of pesticides as cancer causing agents, evidence is lacking to implicate all but a few. As most cancers are caused by a number of factors, it is extremely difficult to determine whether or not a particular cancer resulted specifically from pesticide exposure or other factors. Apart from organochlorines and arsenic, which are now banned, only chlorothalonil, dichlorvos and amitrole have been classified as possible (less weight of evidence than probable) carcinogens by the World Health Organisation.

**Endocrine disruption**
The endocrine system is made up of many glands in the body and the hormones they secrete. These hormones guide the development, growth, reproduction and behaviour of all animals including humans. Some of the glands include females’ ovaries and males’ testes. Endocrine disruptors are chemicals that interfere with the normal functioning of the endocrine system. Large, acute exposure to some chemicals, such as the organochlorines, has caused adverse effects to the endocrine systems of animals.

The best way to manage health risks from chronic pesticide use is to reduce exposure by following all the directions on pesticide labels.

**Pesticides and the environment**
Most insecticides are toxic to aquatic organisms, bees and birds. Fungicides and herbicides are relatively safe to bees in terms of their active ingredients, but their carriers and surfactants can be toxic. The risks that a particular product poses to the environment are reflected in statements on the label under headings such as ‘Protecting wildlife, fish, crustacea and the environment’.

**Protecting the aquatic environment**
The risk to aquatic organisms can be managed by:

- preventing drift into surface waters during application
- locating the mixing, loading and decontaminating facilities away from surface waters and providing these facilities with bunding and sumps to prevent movement of either concentrate or rinsate into surface waters
- installing valves that prevent backflow when filling spray tanks from surface waters and in
suction lines for chemigation systems which draw directly from surface waters
• avoiding aerially applying spray onto fields under irrigation
• building sufficient on-farm storage capacity (including provision for storm run-off) to contain pesticide-contaminated tailwater from irrigation
• spraying in an upstream direction when it is necessary to spray near surface waters; this will reduce the maximum concentration at any one point in the watercourse
• using only registered products to control aquatic weeds, e.g. Roundup® Biactive rather than Roundup®
• avoid disposing of used containers in surface waters, on flood plains or river catchments.

Protecting bees
Many pesticides are toxic to bees and can damage the productivity of hives if bees or the hives are contaminated. Some pesticides are particularly toxic to bees and these pesticides will have the following statement on the label:
Dangerous to bees. Do not spray any plants in flower while bees are foraging.

The pesticide risk to bees can be reduced by:
• only applying pesticides toxic to bees when bees are not foraging i.e. early in the morning or later in the evening
• notifying the apiarist when beehives are in the vicinity of crops to be sprayed to allow them time to remove the hives before spraying
• where possible, using emulsifiable concentrate (EC) and granular formulations in preference to wettable powders, which are particularly hazardous to bees. Microencapsulated formulations are particularly hazardous to bees because of their persistence in the environment and because bees transport the micro-capsules back to the hive along with pollen
• using ground rigs rather than aerial application to minimise drift, especially when crops and adjacent plants are flowering
• avoiding drift and surface water contamination where bees drink (see Protecting the aquatic environment).

Protecting birds
Organophosphate and carbamate insecticides can be particularly toxic to birds, especially in granular formulations. Bird kills from diazinon and carbofuran (neither of which are recommended in this guide) have been well documented in Australia and overseas. Insecticidal seed dressings can pose similar risks; just a few seeds or granules can be lethal to birds. Spillages can be very hazardous to birds as they can easily ingest a toxic dose from a small area. Risks to birds from granular products can be managed by:
• ensuring complete incorporation beneath the soil, particularly at row ends where spillage can occur
• immediately cleaning up any spillage, however small.
Bait materials to control rodents or soil insect pests can also be hazardous to birds, either through direct consumption of the bait or from feeding on bait-affected animals or pests. The risks to birds from baits can be managed by:
• ensuring even bait distribution, with no locally high concentrations
• not baiting over bare ground or in more open situations, such as near crop perimeters, where the baits are more likely to be seen
• not baiting near bird habitats such as remnant native vegetation
• using bait stations, which prevent access by birds, particularly near bird habitats
• only baiting where pest pressure is high
• baiting late in the evening when birds have finished feeding
• promptly collecting and burying rodent carcasses where these occur in open situations
• immediately cleaning up any spillage, however small.
Insecticide sprays can also be hazardous to birds, either because of direct contact with the sprayed chemical, or by feeding on sprayed insect pests or crops. Even where birds are not killed, they can be sufficiently affected to make them more vulnerable to predation. Contaminated seed and insects collected from sprayed fields by parent birds can also be lethal to young chicks still in the nest. Risks to feeding and nesting birds can be managed by:
• minimising drift into remnant vegetation, wildlife corridors, nesting sites or other bird habitats
• actively discouraging birds from feeding in crops that are to be sprayed
• spraying late in the day when birds have finished feeding
• using only low toxicity chemicals when large concentrations of birds are nesting nearby.
Managing residues resulting from pesticide application

Withholding periods

The withholding period (WHP) is the minimum time that must elapse between the last application of a pesticide and harvest. The purpose of the WHP is to avoid residues of agricultural chemicals and their metabolites exceeding maximum residue limits (MRLs) in raw agricultural commodities and in foods for consumption by humans and animals.

Pesticides used on crops can have WHPs for both harvest and grazing. Harvest WHPs can vary with formulation (e.g. EC or ultra-low volume (ULV)), rate (which can vary with the pest controlled), and whether the crop can be harvested green or dry. Grazing WHPs can vary depending upon whether the crop is grazed or cut for stock food before or after harvest.

WHPs are specific to products and use patterns, i.e. to chemical, crop and pest. Not all labels pick up all registered use patterns. Consequently, not all labels contain the same information on WHPs. Different labels can have different WHPs for the same use pattern.

On some labels the WHP will be within the tables giving Directions for use; on other labels the WHP appears separately below the Directions for use. Where appropriate, growers are advised to contact the chemical manufacturer for advice on managing chemical residues in the crop or stock.

Where no WHP is given on the label, do not assume that the WHP is zero. If there is no WHP, the label will contain a statement to the effect that no WHP is necessary if label directions are followed.

Export requirements

Some export markets either have a lower MRL than Australia or no MRL. Exporters need to identify these requirements by checking directly with the export market. Longer WHPs might be required for some markets to allow the residue to decay to the required level. It is up to the individual producer to be aware of export chemical residue requirements and to amend chemical management practices accordingly.

Permits

A permit is issued for a limited use and a limited time if the Australian Pesticides and Veterinary Medicines Authority (APVMA) is convinced that such a use is justified. Justification is usually on the grounds that an already registered suitable alternative is not available, and that safety and residue concerns are adequately addressed.

It is possible that permits will be granted during the current growing season. Growers wishing to use a chemical in the manner approved under a permit should obtain a copy of the relevant permit from the APVMA and must read and comply with all the details, conditions and limitations relevant to that permit.

Primary producers, organisations and corporations can apply for permits for off-label use. Inquiries should be made through:

Australian Pesticides and Veterinary Medicines Authority (APVMA)
PO Box 6182
Kingston ACT 2604
P: 02 6210 4701
E: enquiries@apvma.gov.au
W: www.apvma.gov.au

Analytical laboratories

In some situations a chemical analysis of fruit might be required. Listed below are examples of laboratories which undertake this type of work:

Agrisearch Analytical
Level 1, 48 Victoria Road
Rozelle NSW 2039
P: 02 9810 3666. F: 02 9810 3866

National Measurement Institute
105 Delhi Road
North Ryde NSW 2113
P: 02 9449 0111. F: 02 9440 0297
WE’VE GOT YOUR BERRIES COVERED

FORTUNA GLOBE
750g/kg Mancozeb

- High loaded Dry-Flowable granule for ease of mixing and minimal dust
- 3 year expiry date
- Control of Botrytis, Rust and Downy mildew in Blackberries, Blueberries and Raspberries

HYDROCOP WG
500g/kg Copper Hydroxide

- Dry-Flowable granule for ease of mixing and minimal dust
- Superior coverage and adhesion due to small particle size
- Control of Anthracnose and Blueberry rust in Blueberries, Rust and Leaf spot in Raspberries and Blackberries

COPPOX WG
500g/KG Copper Oxychloride

- High loaded Oxychloride formulation for lower application rates
- Dry-Flowable granule for ease of mixing and minimal dust
- Control of Anthracnose, Rust and Spur blight in Raspberries

GROCHEM CAPTAN 800 WG
800g/kg Captan

- Multi-site fungicide
- Dry-flowable granule that is low foaming and low odour.
- Control of Anthracnose, Botrytis and Spur blight in Blackberries, Blueberries and Raspberries

CROP DOC 600
600 g/L Phosphorous (Phosphonic) Acid

- Systemic fungicide
- pH buffered solution
- Control of Phytophthora root rot in Blackberries, Blueberries and Raspberries

Pheromone Attractant for Honey Bees
Liquid formulation containing attractants that direct honey bees to treated blossoms for improved crop pollination and crop yields.

*Always read product labels and permits before use.
Spray drift

What is spray drift?
Spray drift is the airborne movement of chemicals with the potential to cause injury or damage to humans, plants, animals, the environment or property, onto a non-target area. All pesticides are capable of drift. People have a moral and legal responsibility to prevent pesticides from drifting and contaminating or damaging neighbours’ crops and sensitive vegetation areas. In areas where a range of agricultural enterprises co-exist, conflicts can arise, particularly from pesticide use. Some labels now carry spray drift management instructions including buffer zones. You should always read and follow all label instructions.

Types of drift
Droplet drift is the most common cause of off-target damage from pesticide application. It is also the easiest to control because, under good spraying conditions, droplets are carried down by air and gravity to collect on plant surfaces.

Particle drift occurs when water and other pesticide carriers evaporate quickly from the droplet, leaving tiny particles of concentrated pesticide. Susceptible crops up to 30 km from the source can be damaged by particle drift.

Vapour drift is confined to volatile herbicides such as 2,4-D ester and 2,4-D amine. Vapours can arise directly from the spray or evaporation from the sprayed surfaces. Using 2,4-D ester in summer can lead to vapour drift damage to highly susceptible crops such as tomatoes, sunflowers, soybeans, cotton and grapes. Vapour drift can occur hours after the herbicide has been applied.

Vapours and minute particles float in the airstream and are poorly collected on catching surfaces. They can be carried for many kilometres in thermal updraughts before being deposited.

Factors affecting chemical spray drift
Any herbicide, fungicide or insecticide can drift. The drift hazard, or off-target potential of a chemical in a particular situation, depends on the following factors:

Volatility of the formulation
Volatility refers to the likelihood that the chemical will evaporate and become a gas. Esters volatilise (evaporate) more readily than amine formulations. Many ester formulations are highly volatile when compared with the non-volatile amine, sodium salt and acid formulations. Some low volatile ester formulations can contain high volatile esters, so always be careful when using these products.

Proximity of crops
The closer you are spraying to susceptible crops, the higher the risk of spray drift damage.

Amount of active ingredient
The more applied per hectare, the greater amount available to drift or volatilise.

Efficiency of droplet capture
Bare soil does not have anything to catch drifting droplets compared with crops, erect pasture species and standing stubbles.

Weather conditions
Wind, temperature and humidity during and shortly after application will influence spray drift.

Application method and equipment used
- aerial application releases spray at ~3 m above the target and uses relatively low application volumes
- ground rigs have lower release heights and generally higher application volumes, with a range of nozzle types
- misters produce large numbers of very fine droplets that are carried by wind.

Sensitive crops can be up to 10,000 times more susceptible than the crop being sprayed. Even small quantities of drifting herbicide can cause severe damage to highly sensitive plants.
Minimising spray drift
Successfully managing spray drift will require a range of complementary strategies to be adopted, including:

Before spraying
• Always check for susceptible crops and sensitive areas such as houses, schools and riparian areas
• Notify neighbours of your spraying intentions
• Under the Records Regulation of the Pesticides Act, it is essential that weather and relevant spray details are recorded.

Identify sensitive areas
Sensitive areas are those where spray drift is likely to have the greatest adverse effects, such as:
• lakes, ponds and waterways
• wildlife habitats and wetlands
• neighbouring houses
• public roads (e.g. those used by school buses)
• schools and other public amenities
• travelling stock routes and reserves
• organic and alternative farming systems.
The potential adverse effects will depend on the exact nature of the sensitive area in relation to the toxicity and chemical formulation used.

Establish appropriate buffer zones
Buffer zones help to minimise drift into sensitive areas. A buffer zone can consist of fallow, pasture, a non sprayed strip of the crop or purpose planted vegetation. Vegetative buffer zones should be sufficiently open to allow the spray to penetrate and of sufficient depth to trap the bulk of any drift.

Property planning
Property plans are a tool for communicating to others, such as spray contractors and neighbours, the factors that need to be considered when applying chemicals on the property. A property plan would include:
• houses and farm buildings
• neighbouring properties
• sensitive areas
• roads and access points
• public roads and public places
• watercourses and storage
• cropping and grazing paddocks
• powerlines and other hazards to aircraft.

Communication
Communicating with adjoining land users is critical in avoiding the conflict that can ensue from drift incidents. Communication can include:
• pre-season discussions with neighbours to identify the type and location of crops to be grown, chemicals to be used and potential adverse effects on neighbours’ activities
• notifying neighbours before applying chemicals
• an agreement on the conditions in which chemical application will not proceed or will be discontinued
• a clearly defined process and timetable for resolving any conflict that might arise
• an agreed process for recourse to regulatory action, if required.

For information on managing chemical application to avoid and minimise spray drift, farmers and applicators should read label directions carefully.

During spraying
• always monitor meteorological conditions and understand their effects on drift hazard
• do not spray if conditions are not suitable, and stop spraying if conditions change and become unsuitable
• record weather conditions (especially temperature and relative humidity), wind speed and direction, pesticide and water rates, and operating details for each paddock
• supervise all spraying, even when a contractor is employed. Provide a map marking the areas to be sprayed, buffers to be observed, sensitive crops and areas
• avoid spraying when temperatures exceed 28 °C
• minimise spray release height (lowest possible boom height)
• use the largest droplets that will give adequate spray coverage. Where droplet size is mentioned on the label, follow the label instructions
• always use the least-volatile pesticide formulation available
• maintain a down-wind buffer that could be in-crop, e.g. keep a boom width from the downwind edge of the field. Where buffer zones are mentioned on the label, follow label instructions
• if sensitive crops are in the area, use the least damaging herbicide.
Compromising between minimising spray drift and achieving the ideal coverage

A significant part of minimising spray drift is selecting the right equipment to reduce the number of small droplets produced. However, this can affect target coverage and the possible effectiveness of the pesticide application. This needs to be carefully considered when planning to spray. As the number of smaller droplets decreases, so does the coverage of the spray. The water rate might also need to be increased to compensate for coverage.

Reduce spray release height: Operate the boom at the minimum practical height. Drift hazard doubles as nozzle height doubles. If possible, angle nozzles forward 30° to allow a lower boom height with double overlap. Lower heights can lead to more striping, as the boom sways and dips below the optimum height.

Use appropriate nozzles: 110° nozzles produce a higher percentage of fine droplets than 80° nozzles. However, they allow a lower boom height while maintaining the required double overlap. Droplets below 150 microns (Table 38) are extremely prone to drift.

Table 38. ASABE S572 standard droplet size chart.

<table>
<thead>
<tr>
<th>Category and code</th>
<th>VMD (microns)</th>
<th>Colour code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely fine (XF)</td>
<td>&lt;50</td>
<td></td>
</tr>
<tr>
<td>Very fine (VF)</td>
<td>50–150</td>
<td></td>
</tr>
<tr>
<td>Fine (F)</td>
<td>150–250</td>
<td></td>
</tr>
<tr>
<td>Medium (M)</td>
<td>250–350</td>
<td></td>
</tr>
<tr>
<td>Coarse (C)</td>
<td>350–450</td>
<td></td>
</tr>
<tr>
<td>Very coarse (VC)</td>
<td>450–550</td>
<td></td>
</tr>
<tr>
<td>Extremely coarse (XC)</td>
<td>550–650</td>
<td></td>
</tr>
<tr>
<td>Ultra coarse (UC)</td>
<td>&gt;650</td>
<td></td>
</tr>
</tbody>
</table>

Pressure: Operate within the pressure range recommended by the nozzle manufacturer. Fine droplet production increases with increased operating pressure. Lower volumes, such as 30–40 L/ha, produce a higher percentage of fine droplets than higher spray volumes at the same pressure and nozzle design.

Consider the size of the area treated: When large areas are treated, large amounts of pesticide are applied and the total spraying time is increased. This increases off-target risks and the likelihood that conditions such as temperature, humidity and wind direction could change during spraying. Applying volatile formulations to large areas also increases the chances of vapour drift damage to susceptible crops and pastures.

Weather conditions affecting spraying

Midday turbulence: Updraughts during the heat of the day cause rapidly shifting wind directions. Spraying should usually stop by 11.00 am during the summer months.

High temperatures: Avoid spraying when temperatures exceed 28 °C.

Humidity: Avoid spraying when relative humidity is low i.e. when Delta T (the difference between wet and dry thermometers; Figure 121) exceeds 10 °C. Spraying when Delta T is between 8–10 °C is considered high risk. High humidity extends droplet life and can greatly increase the drift hazard from fine droplets under inversion conditions. This results from an increased life of droplets smaller than 100 microns.

Wind: Avoid spraying during calm or still conditions as this is when droplets are more likely to remain suspended in the air. The ideal safe wind speed is 7–10 km/h. Leaves and twigs are in constant motion (a light breeze). Wind speeds of 11–14 km/h (moderate breeze) are suitable for spraying if you are using low drift nozzles or higher volume application (80–120 L/ha). Small branches move, dust is raised and loose paper is moving. When wind speed is greater than 15 km/h, avoid spraying.
Surface inversions

What are surface inversions?
Surface inversions are layers of the atmosphere at the earth’s surface in which temperature increases with height (Figure 122). This is the opposite (inverse) of the normal temperature decrease with height.

Figure 122. Surface inversion layer. Source: Bureau of Meteorology.

Hazards of surface inversions
Surface inversions strongly suppress airborne pesticide (and similar) dispersion. Surface inversions can cause airborne pesticides to:

- remain at high concentrations for long periods over and close to the target
- travel close to the surface for many kilometres in light breezes
- move downslope and concentrate into low lying regions
- be transported, often in unpredictable directions.

Radiation inversions – the most hazardous
Surface inversions usually begin to occur near sunset after heat energy through infrared radiation upward causes the ground to cool. That radiation passes through clear air with little effect. As the ground cools, the air in contact with the ground begins to cool directly through conduction, leading to the lowest layer of air being cooler than higher layers. This is radiation cooling or a radiation inversion.

Inversions caused by radiation cooling are the most hazardous to pesticide applications because they can severely restrict dispersion and promote transport (drift) of the airborne pesticides at high concentrations.

Radiation inversions occur most nights. Only when winds are strong enough to completely mix the lowest layers of the atmosphere, or cloud cover severely restricts surface heating and cooling, is there a chance that surface radiation inversions will not form overnight.

Radiation inversions also form over sloping terrain when the air in contact with the ground is cooled by terrestrial radiation. The cooled layer remains shallow, often only 2–10 m deep, because gravity continually pulls it downward causing drainage winds. Drainage wind advection (horizontal convection) of cool air away from the slope and over or into lower lying regions can initiate a drainage inversion or intensify an existing radiation inversion. Once formed, drainage inversions have similar attributes to radiation inversions. Drainage winds can transport airborne pesticides long distances downhill, over flat terrain toward the lowest lying regions and into valleys.

Radiation and drainage inversions typically begin in the evening at about sunset. This is when the ground surface cools and the air in contact with the surface loses sufficient heat by conduction to become colder than the air immediately above. With continued overnight cooling, inversions usually intensify and deepen up to the time of the overnight minimum temperature. Radiation and drainage inversions have caused substantial damage in various crops previously.

How to anticipate and recognise radiation inversions
The potential for inversions to occur and to adversely hold high concentrations of airborne pesticides near the surface should always be anticipated between sunset and up to an hour or two after sunrise, unless one or more of the following conditions occur:

- there is continuous overcast, low, heavy cloud
- there is continuous rain
- wind speed remains above 11 km/h for the whole period between sunset and sunrise.

However, be aware that established inversions can sometimes still occur when winds are in excess of 11 km/h.

Never spray during a surface inversion.
For more information on inversions, refer to:


Where to find helpful meteorological information

Ideally, real time data should be collected in the paddock when spraying. This can be done with handheld units, on-farm weather stations or mobile phone apps that measure temperature, Delta T and wind speed.

Hourly data

Forecasts are available from a number of websites. Hourly data from the Bureau of Meteorology (BOM) weather stations for the previous 72 hours can help with planning spray activities and is useful for developing an understanding of the current daily patterns of meteorological conditions.

Meteograms™

Meteograms™ are very helpful in planning spray programs for periods of lowest drift risk and highest pesticide efficacy. They are mostly available by subscription. Some examples can be found at Weatherwise (www.weatherzone.com.au/models/meteogramdrill.jsp), or Spraywise decisions (www.spraywisedecisions.com.au). Meteograms™ provide seven-day forecasts of temperature, relative humidity, Delta T, rainfall and wind speed and direction.

Further information

Further information about weather conditions and spraying can be found at:

Disposing of farm chemicals and their containers

After chemicals have been applied according to the label directions, empty chemical containers and any unused chemicals must be disposed of in an environmentally responsible manner. Containers can be recycled through drumMuster while chemicals should be disposed of through ChemClear.

**drumMUSTER**

drumMUSTER provides Australian agricultural and veterinary (agvet) chemical users with a recycling pathway for eligible empty agvet chemical containers. Developed with the environment in mind, the drumMUSTER program collects and recycles eligible, clean agvet containers.

Working with local councils and other collection agencies, drumMUSTER has established collection facilities all over Australia. Since its inception in 1998, 32 million containers have been recycled.

Once containers are collected, they are recycled into re‑usable products such as wheelie bins, road signs, fence posts and bollards.

The drumMUSTER service benefits users, the environment, industry and the wider community by providing a reliable, cost effective and sustainable option for recycling empty eligible agvet chemical containers.

Disposing of these containers in the right way is crucial to the reputation and sustainability of the agricultural industry in Australia. By using the drumMUSTER recycling program you can turn your unwanted containers into useful, sustainable products rather than having them placed into landfill or building up on‑farm.

Cleaning containers for collection

When rinsing chemical containers, the personal protective equipment (PPE) specified on the label for application, mixing or loading the pesticide should be worn. This is because the chemical remaining in a container is the concentrate; the most toxic form of the chemical, even though it is diluted during rinsing.

Rinsing is the most effective method while the containers are still moist inside. The longer the residues have to dry and cake on the inside of containers, the more difficult they are to remove. This is why rinsing during mixing and loading is preferred, because the rinsate can be emptied into the spray or mixing tank and it can be used for its desired application. Using the rinsate in this way avoids the necessity for having to dispose of the container residues separately.

To triple rinse a container up to 20 L to meet drumMUSTER standards:

1. remove the cap, invert the container and allow it to drip drain into the mixing tank for 30 seconds
2. add rinse water – 20% of container volume (e.g. 1 L per 5 L)
3. replace the cap and shake vigorously for one minute
4. remove the cap, invert and drip drain into mixing tank for 30 seconds
5. repeat twice
6. wash the cap separately and replace on the container.

Note: Triple rinsing is only suitable for small containers, up to 20 L.

Alternatively, use a pressure nozzle to triple rinse small containers. There are two main types of nozzle. One has a rotating spray head which can be used either to rinse an inverted container in the induction hopper or directly over the tank. The other type has a hardened, pointed shaft to pierce drums and the hollow...
shaft itself has four holes at 90° to spray the water around the container.

To pressure rinse a container up to 20 L:
1. remove the cap, invert the container and allow it to drip drain into the mixing tank for 30 seconds
2. ensure clean rinse water is at 35 – 60 psi
3. insert the pressure rinsing probe either into the container opening or through the pierced base of the container (depending on the type of nozzle)
4. invert the container over the mixing tank and rinse for 30 seconds or longer if the water coming from the container neck is not clear, moving the probe about to ensure all inner surfaces are rinsed
5. wash the cap in clear rinse water
6. turn off the water, remove the probe and drip drain the container into the mixing tank for 30 seconds
7. replace the lid on the container.

Large containers, e.g. 200 L, are best rinsed with a chemical transfer probe that has a flushing cycle as well as the primary suction cycle. Such probes are standard on many boom sprays, and optional on most others. The drums might have to be slightly inclined to ensure all rinsate is removed. Typical rinse time for a 200 L drum would be 3–5 minutes.

Non‑rigid containers, i.e. bags and cartons, have to be buried (see Disposal of rinsate or dilute chemical on this page for conditions). Plastic bags should be rinsed first, and paper bags punctured or shredded. Cartons also have to be punctured or shredded before burial.

Burning is specifically prohibited.

For more information, visit www.drummuster.com.au or call 1800 008 707.

ChemClear
ChemClear provides Australian agvet chemical users with a collection and disposal pathway for their unwanted chemicals. ChemClear compliments drumMUSTER by providing agvet chemical users with a recycling and disposal option. Both programs are funded by AgStewardship Australia Limited through a 4 c per litre levy placed on participating manufacturers’ products and passed on to consumers at the point of sale.

ChemClear® collects two categories of agvet chemicals:

**Group 1** chemicals are those which are currently registered products manufactured by participating companies signed into the Industry Waste Reduction Agreement. These products are collected free of charge.

**Group 2** chemicals are those products which are manufactured by non-participating companies, or, deregistered, unknown, mixed or out of date products (by two years). A per litre/kilogram fee for disposal applies.

For more information or to register for the program, visit www.chemclear.com.au or call 1800 008 182.

Disposal of rinsate or dilute chemical
Labels contain a prohibition on disposing of concentrate on‑site or on‑farm, as per state environmental legislation. The unused chemical has first to be diluted and, if not applied in terms of the label use pattern, has to be disposed of in an environmentally responsible manner, such as an evaporation pit. This pit should be a metre deep, lined with plastic sheeting over which has been spread hydrated lime, and any waste covered with at least half a metre of soil. Disposal pits are only suited to small volumes and for diluted chemicals. In the case of a concentrate spill, the chemical would have to be diluted to at least standard label rates before transfer to the disposal pit.
Avoiding pesticide resistance

Resistance of a pest or disease to a specific chemical occurs when the chemical no longer provides the control it did previously. Repeatedly spraying populations of pests and diseases with a particular chemical can cause resistance. All populations contain very small numbers of individuals that are resistant to a given pesticide. Continuing to use the pesticide will kill susceptible individuals, but 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 now an important consideration when choosing a control strategy. One strategy is rotating chemical groups so that the weed, fungus, pest or disease is not being repeatedly treated with the same type of chemical.

All registered pesticides have a symbol on the label which 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. Identification scheme has also been set up for both herbicides and fungicides.

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 with the conditions as directed. Complying with resistance management instructions will help to minimise resistance.

Predatory mites
If two-spotted mite is a problem and predatory mites have not previously been detected in the orchard, or if predatory mites no longer respond to an increase in the pest mites, consider releasing predatory mites.

Insecticides
Unfortunately the berry industry in NSW and QLD relies heavily on the same group of chemicals (1A and 1B), limiting rotation options. However, the option is there and must be used to prevent resistance to the few chemicals we still have available. In the early stages of plant production for pre-flowering and flowering pests, options are limited to a range of 1A products. At later stages of berry development, preference should be given to products that are not in the 1A group and have short WHPs.

A typical scenario could be to spray thrips early with a 1A product at flowering, but avoid foraging bees. Continue monitoring regularly for pests at this critical stage. Another product might be required later during flowering. Then, just before harvest, there is an opportunity to use a different chemical group, e.g. 3A.

Suggestions in the remarks column of the tables in this guide are designed to help growers decide how to rotate their chemical use to avoid resistance.

Research to continually screen the effectiveness of new chemical formulations as they become available should be ongoing. Additionally, this research should also involve identifying ways that these new formulations can be incorporated into the spray program to achieve better integrated pest management (IPM) strategies.

Fungicides
Fungicide resistance arises because most of the newer fungicides are very specific in their effects on fungal cells. In any collection of spores, a very low number will be resistant to a specific fungicide. If we use the same fungicide repeatedly, we allow these spores to multiply, while killing those that are susceptible to the chemical, until almost all of the spores are resistant to, and unaffected by, the fungicide. If we then use a fungicide with a different mode of action, we can control the new strain, but damage to the crop is already done.

Avoiding fungicide resistance
Generally, horticultural crops have a variety of fungicides to prevent resistance build up. Rosalie Daniel, Plant Pathologist NSW DPI, developed an Anthracnose and Botrytis control management strategy. In this, she has suggested which products are available to the industry that can be used without causing resistance (Table 39).
Avoiding pesticide resistance

Available products to prevent blueberry rust, the industry's main disease concern for interstate market access, are limited. A similar management strategy for blueberry rust that would also comply with Interstate Certification Assurance (ICA31) is in Table 40. Alternative products should be used when market advantages such as ICA are not required.

When a fungus develops resistance to a particular fungicide, it will often also be resistant to related chemicals. Therefore, when selecting a disease control program, always ensure that the chemicals come from different MOA groups (Table 41 and Table 42).

If demethylation inhibitors (DMI) fungicides are used alone, do not use more than four applications, then follow with a protective fungicide within seven days. If more than four DMI applications are required, subsequent sprays should be mixed with a protective fungicide that has a different mode of action to the DMIs. Refer to product labels for anti-resistance strategies.

Specific recommendations for avoiding fungicide resistance are now shown on many labels and the chemicals are classified into groups. The main groups shown in Table 41 correspond with those adopted by the agrochemical industry through CropLife Australia. Only fungicides recommended in this guide are shown.

Table 39. Example Anthracnose and Botrytis management strategy.

<table>
<thead>
<tr>
<th>Spray strategy</th>
<th>1st spray (before buds open)</th>
<th>2nd spray (14–28 days after 1st spray)</th>
<th>3rd spray (14–28 days after 2nd spray)</th>
<th>4th spray (14–28 days after 3rd spray)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper (before fruit set)</td>
<td>Chlorothalonil*</td>
<td>Switch*</td>
<td>Captain</td>
</tr>
<tr>
<td>2</td>
<td>Scala*</td>
<td>Chlorothalonil*</td>
<td>Copper</td>
<td>Switch*</td>
</tr>
<tr>
<td>3</td>
<td>Chlorothalonil*</td>
<td>Scala*</td>
<td>Captan</td>
<td>Captain</td>
</tr>
<tr>
<td>4</td>
<td>Scala*</td>
<td>Copper</td>
<td>Chlorothalonil*</td>
<td>Switch*</td>
</tr>
</tbody>
</table>

* 28-day WHP.

Table 40. Example blueberry rust control strategy.

<table>
<thead>
<tr>
<th>Spray strategy</th>
<th>1st spray (early, before rust is visible)</th>
<th>2nd spray (14 days after 1st spray)</th>
<th>3rd spray (14 days after 2nd spray)</th>
<th>4th spray (14 days after 3rd spray)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mancozeb</td>
<td>Tilt*</td>
<td>Mancozeb</td>
<td>Pristine*</td>
</tr>
<tr>
<td>2</td>
<td>Chlorothalonil*</td>
<td>Mancozeb</td>
<td>Tilt*</td>
<td>Pristine*</td>
</tr>
<tr>
<td>3</td>
<td>Mancozeb</td>
<td>Chlorothalonil*</td>
<td>Pristine*</td>
<td>Tilt*</td>
</tr>
<tr>
<td>4</td>
<td>Mancozeb</td>
<td>Mancozeb</td>
<td>Pristine*</td>
<td>Tilt*</td>
</tr>
</tbody>
</table>

* Not for ICA 31.

Table 41. Fungicide groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Chemical class</th>
<th>Common name</th>
<th>Example trade name*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Benzimidazole</td>
<td>Carbendazim</td>
<td>Spin Flo*</td>
</tr>
<tr>
<td>2</td>
<td>Dicarboximide</td>
<td>Iprodione</td>
<td>Rovral*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Procymidone</td>
<td>Sumisclex*</td>
</tr>
<tr>
<td>3</td>
<td>Triazole</td>
<td>Propiconazole</td>
<td>Tilt*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difenconazole</td>
<td>Score*</td>
</tr>
<tr>
<td>4</td>
<td>Phenylamide</td>
<td>Metalaxyl</td>
<td>Ridomil*</td>
</tr>
<tr>
<td>4 + M1</td>
<td>Phenylamide + inorganic</td>
<td>Metalaxyl + copper hydroxide</td>
<td>Ridomil Gold Plus*</td>
</tr>
<tr>
<td>7, 11</td>
<td>Carboxamides + methoxy carbamates</td>
<td>Boscalid + pyraclostrobin</td>
<td>Pristine*</td>
</tr>
<tr>
<td>8</td>
<td>Hydroxy pyrimidine</td>
<td>Bupirimate</td>
<td>Nimrod*</td>
</tr>
<tr>
<td>9</td>
<td>Anilinopyrimidines</td>
<td>Pyrimethanil</td>
<td>Scala*</td>
</tr>
<tr>
<td>9, 12</td>
<td>Anilinopyrimidines + PhenylPyrroles</td>
<td>Cyprodinil + fludioxonil</td>
<td>Switch*</td>
</tr>
<tr>
<td>11</td>
<td>Quinone</td>
<td>Pyroclastrobin</td>
<td>Scholar*</td>
</tr>
<tr>
<td>12</td>
<td>Phenylpyrrole</td>
<td>Fludioxonil</td>
<td>Agrifos*</td>
</tr>
<tr>
<td>33</td>
<td>Ethyl Phosphonate</td>
<td>Phosphonic acid</td>
<td>Phospot*</td>
</tr>
<tr>
<td>33/Y</td>
<td>Ethyl Phosphonate</td>
<td>Phosphonic acid</td>
<td>Phospot*</td>
</tr>
<tr>
<td>M1</td>
<td>Inorganic</td>
<td>Copper fungicides</td>
<td>Kocide*</td>
</tr>
<tr>
<td>M2</td>
<td>Inorganic</td>
<td>Sulfur as polysulfide</td>
<td>Lime Sulfur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulfur (elemental)</td>
<td>Thiovit*</td>
</tr>
<tr>
<td>M3</td>
<td>Dithiocarbamate</td>
<td>Mancozeb</td>
<td>Dithane*</td>
</tr>
<tr>
<td>M4</td>
<td>Phthalimide</td>
<td>Captan</td>
<td>Orthocide*</td>
</tr>
<tr>
<td>M5</td>
<td>Chloronitrile</td>
<td>Chlorothalonil</td>
<td>Bravo*</td>
</tr>
</tbody>
</table>
Table 42. Insecticide and miticide groups\textsuperscript{1,2}.

<table>
<thead>
<tr>
<th>Group</th>
<th>Chemical class</th>
<th>Common name</th>
<th>Example trade name*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Carbamate</td>
<td>Carbaryl</td>
<td>Bugmaster Flowable®</td>
</tr>
<tr>
<td></td>
<td>Methomyl</td>
<td>Lannate L*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pirimicarb</td>
<td>Aphidex®</td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>Organophosphate</td>
<td>Azinphos-methyl</td>
<td>Gusathion®</td>
</tr>
<tr>
<td></td>
<td>Chlordprifos</td>
<td>Lorsban®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diazinon</td>
<td>Diazol®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fenthion</td>
<td>Lebaycid®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maldison</td>
<td>Fyfanon®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methidathion</td>
<td>Suprathion®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Omethoate</td>
<td>Folimat®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prothiofos</td>
<td>Tokuthion®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trichlorfon</td>
<td>Dipterex®</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pyrethroid</td>
<td>Alpha-cypermethrin</td>
<td>Fastac Duo®</td>
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<tr>
<td></td>
<td>Bifenthrin</td>
<td>Talstar®</td>
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<td></td>
<td>Tau-fluvalinate</td>
<td>Mavrik Aquaflow®</td>
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<tr>
<td>4</td>
<td>Neonicotinoid</td>
<td>Imidacloprid</td>
<td>Confidor®</td>
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<td></td>
<td>Thiacloprid</td>
<td>Calypso®</td>
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<tr>
<td>5</td>
<td>Spinosyn</td>
<td>Spinosad</td>
<td>Success 2®</td>
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<td>Spinetoram</td>
<td>Delegate®</td>
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<td>6</td>
<td>Avermectin</td>
<td>Abamectin</td>
<td>Vertimec®</td>
</tr>
<tr>
<td>7B</td>
<td>Juvenile hormone mimic</td>
<td>Fenoxyocard</td>
<td>Insegar®</td>
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<tr>
<td>9B</td>
<td>Feeding blocker</td>
<td>Pymetrozine</td>
<td>Chess®</td>
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<tr>
<td>10A</td>
<td>Tetrazine</td>
<td>Clofentezine</td>
<td>Apollo®</td>
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<td></td>
<td>Thiazolodine</td>
<td>Hexythiazox</td>
<td>Calibre®</td>
</tr>
<tr>
<td>10B</td>
<td></td>
<td>Etoxazole</td>
<td>Paramite®</td>
</tr>
<tr>
<td>11</td>
<td>Microbial</td>
<td>Bacillus thuringiensis</td>
<td>Dipel®</td>
</tr>
<tr>
<td>12B</td>
<td>Organotin</td>
<td>Fenbutatin oxide</td>
<td>Torque®</td>
</tr>
<tr>
<td>12C</td>
<td>Propargite</td>
<td>Betamite®</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Pyrrole compound</td>
<td>Chlorfenapyr</td>
<td>Secure®</td>
</tr>
<tr>
<td>16</td>
<td>Thiadiazine</td>
<td>Buprofezin</td>
<td>Applaud®</td>
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<tr>
<td>18</td>
<td>Diacylhydrazine</td>
<td>Methoxyfenozide</td>
<td>Prodigy®</td>
</tr>
<tr>
<td>21A</td>
<td>Mite growth inhibitor</td>
<td>Tebuifenpyrad</td>
<td>Pyranica®</td>
</tr>
<tr>
<td>22A</td>
<td>Oxadiazine</td>
<td>Indoxacarb</td>
<td>Avatar®</td>
</tr>
<tr>
<td>28</td>
<td>Diamide</td>
<td>Chlorantraniliprole</td>
<td>Altacor®</td>
</tr>
<tr>
<td>UN</td>
<td></td>
<td>Bifenazate</td>
<td>Acramite®</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Trade names which include the common name are not listed. Source: www.apvma.gov.au and CropLife Australia.
\textsuperscript{2} The information in the table shows fungicide and insecticide groups based on the mode of action only. For a chemical’s compatibility with IPM, please see the chemical listings for individual crops.

* Example only. Other products registered.

\begin{center}
\textbf{Never rely solely on one type of chemical for whole of season disease and pest control, no matter how effective it seems; use at least two chemicals with different modes of action.}
\end{center}
Publications
Several publications are mentioned in this guide. Many are available from NSW DPI through Tocal Agricultural College bookshop. Contact details: p: 1800 025 520 e: tocal.college@dpi.nsw.gov.au w: www.tocal.nsw.edu.au/publications

A growing range of our publications are available as eBooks and can be purchased through Apple iBooks and GooglePlay. If you own a tablet or other reading device, here are a few reasons why you should check out our eBooks:

• **Price:** We sell eBooks at half the price of printed books, and there is no added postage.

• **Convenience:** You can buy and download them instantly.

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• **Up-to-date:** If a book is updated (e.g. to incorporate a change in best practice or legislation) the iBook Store sends you a notification to download a new copy of the book for free.

• If you have an Apple iPad, you will be able to download the enhanced multitouch books (selected titles only). This format offers an interactive experience where the books come alive with features such as image galleries, videos, scrolling text and more.

Search for them in GooglePlay, iTunes and iBooks, or visit www.tocal.nsw.edu.au publications for information and links.

**Primefacts** usually contain illustrations of the pest or disease the Primefact describes. These are available free from NSW Department of Primary Industries website (www.dpi.nsw.gov.au/content/agriculture/horticulture/berries).

**Spray Sense** provides information on pesticide issues, which has recently been expanded and upgraded. Topics covered include sprayer calibration, testing for residues, storing pesticides, disposal of empty containers, how to read a label and a number of other topics.

Download **Spray Sense** free from the DPI website (www.dpi.nsw.gov.au/content/agriculture/farm/chemicals/general/spray-sense-leaflet-series).


**A pocket guide to IPM scouting in highbush blueberries,** 2004, Annemiek Schilder and Rufus Isaacs. Michigan State University Bulletin E2928. This ute guide is excellent for identifying some diseases and nutritional problems in blueberries. Unfortunately, as it is an overseas publication, it does not include many of the pests and diseases we have here in Australia.

**Blueberries for growers, gardeners, promoters,** 2006, Norman F Childers and Paul Lyrene, Institute of Food and Agricultural Sciences, Horticultural Sciences Department, University of Florida, Gainesville 32611. This edition is good background reading for growers and plant propagators, covering topics on production trends in North America, varietal breeding and propagation techniques.

**Raspberries** Crop Production Science in Horticulture, No. 23, 2013, R Funt, Ohio State University, USA; H Hall, Shekinah Berries Ltd., New Zealand. A very useful book for raspberry growers. The book covers topics such as propagation, soil and water management, pest and disease management and production.

**Blackberries and their hybrids** Crop Production Science in Horticulture 2017, H Hall, Shehinah Berries Ltd., New Zealand; R Funt, Ohio State University, USA. A very useful book for growers
of blackberries and their hybrids. The book covers topics such as growth and development, plant nutrition and pest and disease management.

**Internet sites**

**Agricultural industry organisations**
International Blueberry Organisation: [www.internationalblueberry.org](http://www.internationalblueberry.org)
National Farmers Federation: [www.nff.org.au](http://www.nff.org.au)
NSW Farmers’ Association: [www.nswfarmers.org.au](http://www.nswfarmers.org.au)

**State government**
Department of Primary Industries and Regional Development: [www.agric.wa.gov.au](http://www.agric.wa.gov.au)
Department of Primary Industries and Regions, South Australia: [www.pir.sa.gov.au](http://www.pir.sa.gov.au)
Department of Primary Industries, Parks, Water and Environment, Tasmania: [www.dpipwe.tas.gov.au](http://www.dpipwe.tas.gov.au)
Queensland Department of Agriculture and Fisheries, Queensland: [www.daf.qld.gov.au](http://www.daf.qld.gov.au)
The Climate Research Strategy for Primary Industries: [www.ccrspi.net.au](http://www.ccrspi.net.au)

**Rural assistance**


**Federal government**
ABC Rural Department: [www.abc.net.au/rural](http://www.abc.net.au/rural)
Australian Pesticides and Veterinary Medicines Authority: [www.apvma.gov.au](http://www.apvma.gov.au)

**Climate**

**Environment**
NSW Environment Protection Authority: [www.epa.nsw.gov.au](http://www.epa.nsw.gov.au)

**Alternative systems (organics)**
Australian Organic: [www.austorganic.com](http://www.austorganic.com)
Organic Federation of Australia: [www.ofa.org.au](http://www.ofa.org.au)

**Economic information**

**Market price information**

**Technical production information**
CSIRO: [www.csiro.au](http://www.csiro.au)
Blueberry nurseries
Emily Hill Farm
Beaconsfield Road
Emerald VIC 3782
p: 03 5944 3971
w: www.emilyhillfarm.com.au
Glovers Tubes Nursery Propagation
1 Rickards Road
Sandy Beach NSW 2456
p: 02 6656 2338
Moondarra Wholesale Blueberry Nursery
120 Brown Road
Moondarra VIC 3825
p: 03 5165 3238
w: www.moonblue.com.au
Mountain Blue Farms Nursery
Bruxner Highway
Wollongbar NSW 2477
p: 02 6624 8258
w: www.mountainblue.com.au

Raspberry and blackberry nurseries
Berry Plant Micropropagation
325 Eacotts Road
Hoddles Creek VIC 3139
p: Ryan Brightwell 0429 384 577
e: ryan@berryplants.com.au
CleanGROW
460 Rookery Road
Winkleigh TAS 7275
p: Karen Brock 03 6394 4807, 0439 972 793
w: www.cleangrow.com.au
Humphris Nurseries
218–220 Cardigan Road
Mooroolbark VIC 3138
p: James Edge 03 9761 9688, 0438 310 938
e: james@humphris.com.au
w: www.humphris.com.au
Mansfield’s Propagation Nursery
150 Taylors Road
Skye VIC 3977
p: Daniel Mansfield 03 9782 2404
e: daniel@mansfields.net.au
w: www.mansfields.net.au
Ramm Botanicals
255 Pacific Highway
Kangy Angy NSW 2258
p: Ryan Webber 02 4351 2099
e: ryan.webber@ramm.com.au
w: www.ramm.com.au
Director Horticulture  
Dr Shane Hetherington  
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p: 02 6391 3860 m: 0409 314 894

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Leader Southern Horticulture  
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Orange Agricultural Institute  
1447 Forest Road ORANGE NSW 2800  
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p: 02 6391 3155 m: 0419 217 553

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p: 02 6626 1350 m: 0447 081 765

Citrus  
Andrew Creek  
Yanco Agricultural Institute  
Trunk Road 80 YANCO NSW 2522  
e: andrew.creek@dpi.nsw.gov.au  
p: 02 6951 2522 m: 0428 934 952

Steven Falivene  
Dareton Primary Industries Institute  
Silver City Highway DARETON NSW 2717  
e: steven.falivene@dpi.nsw.gov.au  
p: 03 5019 8405 m: 0427 208 611

Macadamias  
Jeremy Bright  
Wollongbar Primary Industries Institute  
1243 Bruxner Highway WOLLONGBAR NSW 2477  
e: jeremy.bright@dpi.nsw.gov.au  
p: 02 6626 1346 m: 0427 213 059

Sub-tropical Bananas  
Matt Weinert  
Wollongbar Primary Industries Institute  
1243 Bruxner Highway WOLLONGBAR NSW 2477  
e: matt.weinert@dpi.nsw.gov.au  
p: 02 6626 1352 m: 0438 644 136

Temperate Fruits  
Kevin Dodds  
Tumut District Office  
64 Fitzroy Street TUMUT NSW 2720  
e: kevin.dodds@dpi.nsw.gov.au  
p: 02 6941 1400 m: 0427 918 315

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Orange Agricultural Institute  
1447 Forest Road ORANGE NSW 2800  
e: jessica.fearnley@dpi.nsw.gov.au  
m: 0437 284 010

Viticulture  
Adrian Englefield  
National Wine and Grape Industry Centre  
Locked Bag 588 WAGGA WAGGA NSW 2678  
e: adrian.englefield@dpi.nsw.gov.au  
p: 02 6933 2720 m: 0428 324 099

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1447 Forest Road ORANGE NSW 2800  
e: amanda.warren-smith@dpi.nsw.gov.au  
p: 02 6391 3953
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 by phoning 1300 795 299.

NSW DPI Biosecurity and food safety
NSW DPI Biosecurity and food safety is the contact point in this state for anyone who requires advice on intrastate or interstate movement of fruit or plants and other issues of a biosecurity nature. In previous editions of this guide, we published contact details for regulatory officers at various locations across New South Wales. The method of contacting NSW DPI Biosecurity and food safety has changed, and all enquiries should now be directed via Plant Health Australia’s Domestic Quarantine Line 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.
“So glad we reported it!

We noticed these plants covering the lake that weren’t there before…

...we called Council and it turned out to be frogbit, a new weed that ruins waterways! They acted fast and our call helped save the lake.”

Always contact your local council weeds officer if you notice unusual plants, or call the NSW Invasive Plants and Animals Enquiry Line 1800 680 244

For more information search ‘frogbit’ in NSW WeedWise at weeds.dpi.nsw.gov.au

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Got weeds?
Get WeedWise!
ONLINE OR IN THE APP STORES
weeds.dpi.nsw.gov.au

Over 300 weed profiles in your pocket!

"brilliant...this app is very, very helpful"
NSW WeedWise
Got weeds? Get WeedWise!

ONLINE OR IN THE APP STORES
weeds.dpi.nsw.gov.au

Over 300 weed profiles in your pocket!
Close to one million views a year
“brilliant...this app is very, very helpful”
Biosecurity Act 2015

By law biosecurity is everybody’s business. Weeds threaten our biosecurity and come under the new Biosecurity Act in NSW.

Every person and organisation needs to do their bit to protect the economy, environment and community from the risks posed by weeds. This is now part of your “general biosecurity duty”

**WHAT CAN YOU DO?**

- use NSW WeedWise to find out about the biosecurity duties for weeds in your area (go to weeds.dpi.nsw.gov.au or get the app)
- talk to your local council weeds officer about weeds on your property
- control and prevent weeds spreading on and from your property

Benevia® provides highly effective cross spectrum protection that rapidly stops insects feeding. Further damage to the plant is reduced, ensuring maximum marketability of your crop.

Benevia® is specifically designed for use in Integrated Pest Management (IPM) schemes, in fact, it’s so effective on pests in Fruiting vegetable and Cucurbit crops that we’re expanding the label to cover Bulb vegetables, Potatoes and Strawberries.

Being a Group 28 insecticide tool to fight pests, it’s important to use Benevia® in accordance with the current Insecticide Resistance Management (IRM) strategy in your area. Remember to rotate with a different mode of action insecticide, as required. Visit www.fmccrop.com.au for more information.