Berry plant protection guide
2016–17

Phillip Wilk, Melinda Simpson & Bruce Browne

www.dpi.nsw.gov.au
Berry plant protection guide
2016–17

Phillip Wilk
Development officer–Blueberries
NSW Department of Primary industries

Melinda Simpson
Development officer–Blueberries
NSW Department of Primary industries

Bruce Browne
Technical Specialist Farm Chemicals
NSW Department of Primary Industries
Contents

1 About this guide
  1 Feature articles
  1 Distribution
  1 Pesticides
  1 Acknowledgments
  2 Evaluating urea as a foliar spray to improve blueberry production
  3 Evaluating urea as a foliar spray to improve blueberry production

4 Biosecurity – it’s your responsibility too
  4 Farm biosecurity
  4 Berry biosecurity

20 Development stages for blueberry blossom

22 Good management to control common diseases, pests and disorders in blueberries
  22 Diseases
  26 Pests
  33 Nutrient disorders

36 Orchard management

46 Development stages for raspberry blossom

47 Good management to control common diseases, pests and disorders in raspberries and blackberries
  51 Pests

55 Orchard management: raspberries and blackberries

62 Weed management
  62 Why manage weeds?
  62 Hygiene comes first
  62 Management strategies and control options

66 Biological control
  66 Beneficial insects and mites
  67 Bacterial insecticides

68 Publications

69 Internet sites for berry growers
  69 Agricultural industry organisations
  69 State government
  69 Rural assistance
  69 Federal government
  69 Climate
  69 Environment
  70 Alternative systems (organics)
  70 Economic information
  70 Market price information
  70 Technical production information
  70 Agencies & universities
  70 Integrated pest management
  70 Quality assurance
  70 Post-harvest
  70 Blueberry nurseries
  70 Raspberry and blackberry nurseries
  70 Berry marketing and agents

71 Managing your legal responsibilities in applying pesticides
  71 Pesticides Act
  72 Hazardous chemicals legislation
  72 Pesticides and worker safety
  75 Managing residues resulting from pesticide application
  75 Permits
  75 Analytical laboratories

76 Managing spray drift

80 Disposal of farm chemicals and their containers
  80 drumMUSTEr
  81 ChemClear

82 Timing, calibration and coverage for berries

83 Useful conversions
  83 Standard formula – amount per 100 L
  83 Some examples

84 Examples of spray record documents
  84 How to fill out your pesticide application record

86 Avoiding resistance to pesticides
  86 Resistance management
  86 Miteicide resistance: a case study from the apple industry
  87 Predatory mites
  87 Insecticides
  87 Fungicides
  87 Avoiding fungicide resistance

89 Key DPI contacts
  89 Regulatory staff
  90 Horticultural contacts
  92 Local Land Services contacts
About this guide

This is the first edition edition of the *Berry plant protection guide*. This guide succeeds last year’s *Blueberry plant protection guide* and now includes information on raspberries and blackberries as well as blueberries. It is the latest in a series of similar publications that have served industry for over 56 years, providing up-to-date information on all aspects of protecting your orchard from pests and diseases. This edition will be available through the NSW Department of Primary Industries website in a portable document format (pdf).

**Feature articles**

Dr Sophie Parks, Research Horticulturist in Plant Nutrition with NSW Department of Primary Industries at Ourimbah.

The nutrient requirements of southern highbush blueberry varieties grown as an evergreen system have not been fully established. However, it is common practice to use foliar sprays in April/May to boost nutrition just before the weather cools to better retain leaves on the plant and to avoid production losses. This article provides up-to-date research on applying urea as a foliar spray to improve blueberry production.

**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. As indicated above, 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 in the body of the guide. 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. Unfortunately this practice 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.

» Our use of common chemical names in recommendations in the guide is intended to simplify the advice. It does mean that at least one product containing that active ingredient is registered for the purpose given. The onus is on the user of a pesticide product to ensure that the use of that product is consistent with the label or a permit issued by the APVMA.

» Use of pesticides is under constant scrutiny through residue surveys. It is imperative that these valuable tools for fruit production are not misused.

**Acknowledgments**

We thank the officers of NSW Department of Primary Industries and other organisations who have helped to produce the guide. 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 may improve the usefulness and relevance of the guide.
Evaluating urea as a foliar spray to improve blueberry production

By Dr Sophie Parks
NSW Department of Primary Industries, Ourimbah

Introduction

The nutrient requirements of southern highbush varieties grown as an evergreen system have not been established. However, it is common practice to use foliar sprays in April/May to boost nutrition just before the weather cools, to better retain leaves on the plant and to avoid production losses. To understand the value of foliar sprays for blueberries, two trials have been conducted using urea in solution to supply nitrogen to leaves. Water sprays were used as the control. This research has highlighted that urea spray can increase production under nitrogen stress, but potentially at the expense of optimum fruit size. Its effect on other berry qualities is under investigation.

Method

A field trial on the North Coast of NSW conducted in 2014 investigated using a 5% urea solution sprayed once onto blueberry plants early in the season to observe its effect on fruit quality (average berry weight and sugar content). A pot trial followed on the NSW Central Coast in 2015 where the urea solution was sprayed every 2–3 weeks onto leaves to observe fruit production and leaf retention over winter.

Results and discussion

The field trial showed that the urea spray significantly reduced fruit quality by reducing berry weight (Figure 1). Total sugars (as total soluble solids: TSS) and acid (titratable acid: TA) contents were unchanged. In another study, it was shown that increasing the nitrogen supply to blueberry plants was associated with increased flower bud numbers, fruit yields and fruit firmness, but it reduced berry size (Ehret et al., 2014). One study showed that decreasing the density of flower buds in Southern Highbush blueberries could be used to increase vegetative development and fruit size and total soluble solids (Maust et al., 1999). For the current project, several chemical thinners are being evaluated in 2016 to reduce blossom and fruitlet density in a commercial crop on the North Coast of NSW. Their effects on fruit quality (size, firmness, TSS and TA) will also be evaluated.

Figure 1. The mean berry weight of fruit harvested twice from field plants that were sprayed once with foliar nitrogen as a 5% urea solution compared with water-sprayed plants. Leaf nitrogen increased after harvest 1, but this had declined by Harvest 2. There were 11 replicate plants and the control fruits were significantly greater in weight ($p = 0.05$).

As the field trial did not estimate the yield response to foliar urea, the pot trial was used to understand its impact on fruit production and on the amount of foliage occurring over winter. The urea increased total fruit production by increasing the number of fruits produced (Table 1). It is possible that the foliar urea reduced flower drop occurrence. In contrast to the field trial, fruits from the pot trial did not differ in weight when compared with the water-sprayed plants, but the total fruit load was not likely to be sufficient to limit fruit size.
Table 1. Fruit production (total fruit weight and number) as affected by urea foliar spray compared with water spray. Differences are significant at p <0.05 (n = 17).

<table>
<thead>
<tr>
<th>Per plant</th>
<th>Harvest</th>
<th>Urea</th>
<th>Control</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fruit weight (g)</td>
<td>1</td>
<td>23.6</td>
<td>15.1</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>39.2</td>
<td>28.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fruit #</td>
<td>1</td>
<td>17.9</td>
<td>12.4</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>21.6</td>
<td>15.6</td>
<td>0.056</td>
</tr>
<tr>
<td>Mean berry weight (g)</td>
<td>1</td>
<td>1.67</td>
<td>1.51</td>
<td>0.421</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.79</td>
<td>1.77</td>
<td>0.940</td>
</tr>
</tbody>
</table>

The urea spray appeared to enhance the foliage area, but there were not strong differences between these plants and the control plants (Figure 2). Perhaps nitrogen supplied in the growing medium was sufficient for plant growth. Plant nitrogen status was not measured. Had the effect been significant, it could have related to greater leaf retention or to increased growth. What is apparent is that the foliage area was stable over winter, regardless of treatment.

Figure 2. The mean leaf area index per plant, an estimate of foliage growth, over time. Growth appears to be greater for the urea treated plants but the effect was not statistically significant.

Conclusions
The benefit of foliar nitrogen for blueberries is unclear at this stage. We have demonstrated that it enters leaves to affect some plant responses. It could improve leaf nitrogen and production for plants, particularly for those under nitrogen stress, but it is also likely to reduce fruit size. Its use for leaf retention and its effect on other parameters of fruit quality (firmness, TSS and TA) is an area of continued investigation.

Acknowledgements and further information

Good biosecurity practices are essential to protect your property and your industry against the entry, establishment and spread of exotic plant pests and their impacts. Exotic plant pests can affect farmers and industry stakeholders as well as trade and communities. It is important that everyone plays their part in biosecurity by preparing for, and managing, biosecurity threats.

While Australia’s geographic isolation and national quarantine systems provide some protection against harmful exotic pests being introduced, there will always be some risk they will Australia. Natural dispersal, such as by wind, or assisted dispersal from tourism and imports provide pathways for exotic pests to be introduced to our shores.

**Farm biosecurity**

Newly introduced plant pests can easily be spread on plant material, clothing, vehicles and equipment.

**Come clean go clean** as vehicles, farm equipment and people can carry plant pests on and off your property, especially associated with soil or plant material. Clean down between farms, including vehicles and footwear. Use an on-farm vehicle where possible when on a property to prevent cross-infection.

**Signage** should be used to inform visitors that biosecurity practices are in place. Use signage to direct all traffic to a designated parking area where visitors can make themselves known and vehicles and clothing can be assessed for risk.

**Monitor your berries for plant pests** and familiarise yourself and your employees with pests and diseases commonly seen in your crop. Keep an eye out for any new or unusual pests or diseases and make sure employees know who to alert if they spot something unusual.

**Use pest-free propagation material** sourced from reputable suppliers to avoid introducing new pests and diseases to your property.

**Keep records** that allow all materials moving on and off your property to be traced, as well as movement of contractors, vehicles and visitors.

**Report suspect plant pests and diseases** to the Exotic Plant Pest Hotline 1800 084 881.

Figure 3. Biosecurity signage alerts visitors to protect your property.

**Berry biosecurity**

Three of the most threatening exotic plant pests affecting berries overseas are **spotted wing Drosophila** (blueberries and Rubus), **mummy berry disease** (blueberries) and **raspberry crown borers** (Rubus). These plant pests have been identified as high priority exotic plant pests in berry biosecurity plans. Plant Health Australia has prepared the plans in collaboration with industry and technical experts.

Awareness and identifying these plant pests early are essential for successful containment and eradication should they be introduced to Australia. Further information on berry biosecurity and other high priority plant pests is available on the [Plant Health Australia website](http://www.planthealthaustralia.com.au).

If you think you have seen these, or any other exotic plant pest or disease, call the **Exotic Plant Pest Hotline** on 1800 084 881.

An **exotic plant pest** is a disease-causing organism or an invertebrate **not present in Australia** that threatens agricultural production, forestry or native and amenity plants.
**Spotted wing Drosophila** (*Drosophila suzukii*)

**Affected berries:** Blueberries, raspberries, blackberries, boysenberries and strawberries.

**Damage:** Spotted wing Drosophila females attack healthy ripening fruit, depositing eggs under the skin. Larvae develop and feed inside causing fruit breakdown and secondary disease infection.

**Description:** Adults are small yellow–brown flies 2–3 mm long. Adults have red eyes and black stripes across the abdomen. Adults can be distinguished from similar species in Australia by the female’s ability to lay eggs in healthy fruit and by the black spot on the male’s wingtips.

![Figure 4. Adult spotted wing Drosophila (left) and larvae inside strawberry fruit (right) (Hannah Burrack, North Carolina State University, Bugwood.org)](image)

Larvae are cream, 0.6 mm and noticeable in rotting flesh. Affected fruit will break down and become discoloured.

**Spread:** Adults can fly short distances. A larger spread occurs when fruit infested with eggs or larvae is moved.

**Distribution:** Spotted wing Drosophila originates in South-east Asia and has spread rapidly through North America, Europe and Japan’s fruit producing regions.

---

**Mummy berry disease** (*Monilinia vacciniacorymbosi*)

**Affected berries:** Blueberries.

**Damage:** Characteristics include blighted young shoots and a dry fruit rot that mummifies the berries. There is zero tolerance for mummified fruit in the blueberry market.

**Description:** Young shoots wilt with characteristic browning of leaf midribs that occurs in the spring before tan–grey powdery spores develop on infected shoots. As infected berries approach maturity, they turn pink to light brown and develop a wrinkled appearance. Diseased berries eventually shrivel and harden before dropping to the ground and turning black. The final appearance is likened to tiny black pumpkins. The fungus overwinters in dropped berries on the ground before germinating in spring to produce cup-shaped fungal fruiting bodies (apothecia).

**Spread:** Wind and rain spreads fungal spores, which can be transported longer distances on plant material, equipment, vehicles and people.

**Distribution:** Mummy berry is a serious disease that occurs in many blueberry-growing regions of the United States of America (USA).

![Figure 5. Mummy berry infected blueberries on the plant (left) and on the ground (right) with fungal spore cups (arrows) (Jay Pscheidt, Oregon State University)](image)

---

**Raspberry crown borers** (*Pennisetia marginata* and *P. hylaeiformis*)

**Affected berries:** Most Rubus species including raspberries, blackberries and boysenberries.

**Damage:** Larvae burrow into the plant’s lower cane, crown and roots, leading to reduced yield or plant death.

**Description:** Adults are wasp-like in appearance; 25–30 mm long. The body is black with yellow stripes on the abdomen and thorax. Antennae are feathery and curve outward from the head. Adults appear similar to yellow jacket wasps, but with noticeable hairs on the body and wings. Yellow jacket wasps also have short antennae rather than long, curved antennae.

Eggs are reddish brown and deposited on the underside edges of leaves. Larvae have a white body and brown head and grow to 25–38 mm long.

**Spread:** Adults can fly short distances. A larger spread occurs when plants infested with eggs or larvae are moved.

**Distribution:** *P. marginata* is found throughout the USA, Hawaii and in the southern parts of Canada. *P. hylaeiformis* is widespread in Europe.

![Figure 6. (left) Adult raspberry crown borer (Raevan, Maryland USA, flickr.com)](image)

![Figure 7. (right) Larva burrowing in lower cane (Ken Gray Image, Courtesy of Oregon State University)](image)
Bacterial leaf scorch and the glassy winged sharpshooter

What are bacterial leaf scorch and the glassy winged sharpshooter?

The glassy winged sharpshooter (GWSS, *Homalodisca vitripennis*) is a sap sucking insect native to North America. It rarely causes economic damage, however, it is a vector of the bacteria *Xylella fastidiosa* which causes a bacterial disease known as bacterial leaf scorch, Pierce’s disease, phoney peach or citrus variegated chlorosis. *Xylella* causes significant economic impact on fruit and nut trees (including blueberry), ornamental trees, vegetable crops, shrubs, weeds and some field crops. Bacterial leaf scorch causes different symptoms in different hosts but generally causes either stunting or leaf blight diseases and can lead to tree death.

What do they look like?

The adult GWSS is a large leafhopper (12–14 mm long) and is dark brown to black with a cream-white underside. Adults have a large head with a swollen face and large eyes and small cream to pale yellow spots on their heads. They have clear wings with red-brown veins. The females excrete a chalky white substance just prior to laying eggs that accumulates on their sides appearing as white spots. This is then spread over the eggs. The eggs are laid in a single layer side by side in clutches of 3–28 on the undersides of leaves. At first the cluster appears as a greenish blister beneath the leaf epidermis covered by a chalky substance. The leaf tissue turns brown after hatching and remains as a scar. Nymphs are smaller in size than the adults and have a similar body shape but are wingless and grey.

GWSS nymphs and adults feed on the trunk, stems and leaf petioles of plants and excrete vast quantities of liquid waste which can appear like rain under infested trees. The liquid dries to white and can appear like a chalky whitewash on infested plants.
The first sign of bacterial leaf scorch is leaf tissue death (necrosis), usually starting at the leaf tip, giving the blueberry a burnt appearance. There may be leaf yellowing (chlorosis), leaf reddening and/or a dark margin between dead and healthy leaf tissue. These symptoms will appear on individual branches or one half of the plant at first but will eventually spread to the whole plant. New shoots are generally abnormally thin with very few flower buds. Stems then become yellow and plants drop their leaves giving the plant a skeletal appearance. The root system generally appears healthy. The plant dies within approximately two years and the next year surrounding plants express the same symptoms.

**What can they be confused with?**

The GWSS can be confused with other leafhopper species (such as those in the Auchenorrhyncha suborder), however, the adults are larger than most leafhoppers (12–14 mm long) and have a distinctive head shape. However, an expert is required to identify the GWSS to species level.

Bacterial leaf scorch resembles drought symptoms, fertiliser salt burn, herbicide injury and root rot. The roots of infected plants will appear healthy and there is sometimes a dark band between the dead and healthy leaf tissue. The new stems of plants infected with bacterial leaf scorch will appear thin and yellow.

**What should I look for?**

Any signs of leaf death or premature leaf drop should be investigated closely. The most obvious symptom of bacterial leaf scorch is thin yellow new shoots. The best thing you can do is inspect your crop for the presence of GWSS particularly along the trunks, stems and leaf petioles. Watery excrement under infested trees which dries to give a chalky white coating is a sign of GWSS. Yellow sticky traps are used overseas for crop surveillance.
How do they spread?
GWSS adults are capable of flight allowing for localised spread. It is also possible that they could be accidently spread on vehicles or machinery.
Bacterial leaf scorch is spread by the GWSS and in infected planting material. It is not known if Australian leafhoppers can spread bacterial leaf scorch from infected to healthy plants.

Where are they now?
Both GWSS and bacterial leaf scorch are found in North America and some areas of Mexico. They have spread to French Polynesia (Tahiti) and Hawaii.

How can I protect my farm from bacterial leaf scorch and the glassy winged sharpshooter?
You can protect your farm from bacterial leaf scorch and GWSS by regularly checking your property for the presence of new pests and diseases. Check your crop regularly for symptoms such as leaf death, premature leaf drop, stem yellowing or signs of GWSS feeding. Make sure you are familiar with common blueberry pests so when monitoring your crops for pests you will be alert to the possible presence of exotic pests.

If you see anything unusual, call the Exotic Plant Pest Hotline

EXOTIC PLANT PEST HOTLINE
1800 084 881

Disclaimer: The material in this publication is for general information only and no person should act, or fail to act on the basis of this material without first obtaining professional advice. Plant Health Australia and all persons acting for Plant Health Australia expressly disclaim liability with respect to anything done in reliance on this publication.
Japanese beetle

What is the Japanese beetle?
The Japanese beetle (*Popillia japonica*) is a destructive pest with a wide host range of over 300 plant species including small fruits, tree fruits, shade trees, vegetables, field crops, ornamentals and turfgrasses. Significantly impacted host species include blackberry, raspberry, blueberry, grapevine, stone fruit, lime, corn and soybean.

Adult beetles feed on flowers, fruit and foliage causing extensive damage. Larvae, commonly known as white grubs, feed on the roots of many field crops, ornamentals and vegetables.

What does it look like?
Japanese beetles are oval shaped measuring 8 to 11 mm in length and 5 to 7 mm in width. They are metallic green in colour with bronze or coppery-brown wing covers that do not completely cover the abdomen. Below the wing covers, on each side of the abdomen are five patches of white hair with one additional pair on the last abdominal segment.

Larvae appear as C-shaped translucent and creamy white grubs measuring less than 25 mm at maturity. The head is yellowish-brown with strong dark-coloured mandibles and the thoracic body segments each contain a pair of segmented legs.

What can it be confused with?
The Japanese beetle could be confused with green metallic-coloured beetles found commonly in Australia. However the six tufts of white hairs on each side of the Japanese beetle’s abdomen distinguish it from all other similar looking beetles.

Larvae could be confused with scarab beetle larvae, also known as white curl grubs or cockchafers. However the V-shaped arrangement of spines on the last body segment of the Japanese beetle distinguishes this grub from all others.
What should I look for?

Leaf defoliation is the most common sign of Japanese beetle infestation. Adult beetles generally feed from the upper leaf surface, chewing through the tissue between the veins and leaving a lace-like skeleton. Beetles tend to aggregate on foliage, flowers or fruit and often work their way from the upper and outermost parts of the plant, downward. Fruit also shows external feeding damage. Larval feeding damages roots reducing vitality and yield and sometimes leading to plant death.

How does it spread?

Local spread is primarily the result of adults flying short distances (1-3km) to feed. Adult beetles can also be transported as ‘hitchhikers’ on plant material, produce, machinery and packaging while larvae are easily transported in the soil associated with nursery stock.

Where is it now?

The Japanese beetle is native to Japan and is currently present in the USA, Canada, Portugal and Russia.

How can I protect my farm from Japanese beetle?

Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common caneberry pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

EXOTIC PLANT PEST HOTLINE
1800 084 881
Mummy berry

What is mummy berry?
Mummy berry (Monilinia vaccinii-corymbosi) is a fungal disease of wild and cultivated blueberry. It originated in North America, as did the blueberry, and causes a wide range of symptoms including mummified berries and flower, leaf and shoot blight. Mummy berry may be dispersed by insect vectors, air borne spores rain splash or in soil at different stages of its lifecycle. Control is difficult due to its complex lifecycle and losses can reach 80 per cent without treatment.

What does it look like?
Mummy berry causes wilting in shoots and young leaves, and tissue death (necrosis) along leaf veins. Advanced leaf necrosis has a distinctive oak-leaf pattern along the mid-vein. Entire shoots often curl and die, resembling a shepherd’s crook. Grey to tan powdery spores appear at the base of leaves, along the mid-veins and infected flower pedicels during humid weather. Infected flowers are often asymptomatic, however, death of buds and flowers can occur (flower strike).

Young infected berries are usually asymptomatic, however, when they are split open the white fungal growth can be seen replacing the ovaries. As infected berries mature they soften and turn from waxy green to pink or light brown with a wrinkled appearance. As berries mature they harden, shrivel and become pink or pale purple in colour. Infected berries at this stage are known as mummies (or pseudosclerotia) and generally drop off the bush before harvest. Mummies often turn black as the skin wears off and are a pumpkin shape. Mummies left on the soil surface will germinate in spring, forming small cupped mushroom structures known as apothecia. Spores are released from apothecia starting the infection process again.
What can it be confused with?

Mummy berry flower strike can be confused with botrytis blight (Botrytis cinerea) and with phomopsis blight (Diaporthe vaccinii) overseas. The layer of grey to tan powdery spores along the pedicel distinguishes mummy berry from these two pathogens. Unlike phomopsis blight, mummy berry does not cause stem cankers. Boron deficiency can also resemble mummy berry. The two can be distinguished as mummy berry causes an oak leaf pattern of necrosis and grey to tan powdery spores appear at the base of leaves along the mid-veins in high humidity. Mummy berry can also be mistaken for frost injury but when berries are split open they appear rotten and hollow inside. Frost injured berries are rarely white in colour.

What should I look for?

Mummified fruit is the most obvious sign of infection by mummy berry. Mummified fruit are generally pumpkin shaped, drop off the bush before harvest and are pink, pale purple or black in colour. Other fruit symptoms include wrinkling and discoloration of immature fruit. Check underneath leaf litter and in soil for mummified fruit which germinate in spring, forming apothecia. Any signs of shoot or flower blight should be investigated further. Grey to tan powdery spores on flower pedicels or along leaf stalks can indicate mummy berry. Necrosis along the mid and lateral leaf veins, particularly in an oak leaf shaped pattern, is also indicative of mummy berry.

How does it spread?

Mummy berry is spread in different ways at different stages of its lifecycle. The spores (ascospores) responsible for infection of shoots and buds (from apothecia) are airborne, whereas the spores (conidia) responsible for blossom infection are spread via wind, rain splash and on pollinators. Mummy berry can also be spread in soil as it overwinters in mummified berries on the soil surface. Long distance spread is usually through the movement of infected planting material.
Where is it now?

Mummy berry is native to North America. It is also found in South America and was reported in Europe for the first time in 2003.

How can I protect my farm from mummy berry?

Check your crop frequently for the presence of new pests and unusual symptoms. In particular, check your crop for shoot death, flower strike and mummified, wrinkled or discoloured fruit. Also check the soil surface for mummified fruit. Make sure you are familiar with common blueberry pests so when monitoring your crops for pests you will be alert to the possible presence of exotic pests.

If you see anything unusual, call the Exotic Plant Pest Hotline

1800 084 881

Disclaimer: The material in this publication is for general information only and no person should act, or fail to act on the basis of this material without first obtaining professional advice. Plant Health Australia and all persons acting for Plant Health Australia expressly disclaim liability with respect to anything done in reliance on this publication.
Fact sheet

Orange rust

What is Orange rust?
Orange rust is a systemic fungal disease that affects blackberry, black raspberry, dewberry and purple raspberry. The disease does not usually kill plants, however it weakens and stunts them severely, leading to little or no fruit production. Once infected, plants have the disease for life.

The disease occurs in two different forms with very similar symptoms. One form has a short life cycle and is caused by Gymnoconia nitens, while the other form has a long life cycle and is caused by Arthuriomyces peckianus. The short-cycled form is most common on blackberry and dewberry while the long-cycled form is most common on black raspberry. The disease is not known to affect red raspberry.

What should I look for?
Look for the characteristic bright orange spores on the undersides of leaves in spring. These are blister like and waxy at first but soon turn powdery and bright orange. Newly emerging leaves are often stunted, deformed and pale green or yellowish. Heavily infected leaves wither and drop in late spring/early summer. Newly formed infected shoots may appear healthy but are weak and spindly (lack spines). Later in the season, infected canes become bushy with the growth of many short, upright and spindly shoots from the base of the plant that produce little or no fruit.

What can it be confused with?
Orange rust could be confused with other leaf rusts present in Australia including Blackberry orange rust (Kuehnea uredinis) and Blackberry leaf rust (Phragmidium violaceum). Blackberry orange rust produces yellow/orange spores on the stems and undersides of leaves. It can be distinguished from Orange rust by the pin-point size of spores and by the fact they also appear on stems and older blackberry leaves in late summer/autumn rather
than spring. Blackberry leaf rust can be distinguished from Orange rust by the characteristic purple-brown blotches on the upper surface of the leaf with corresponding yellow or black powdery spores on the lower surface of the leaf.

**How does it spread?**

Orange rust spread is favoured by cool, wet conditions. In mid-spring, wind and rain-splash spread spores from infected leaves to the leaf surfaces of nearby uninfected plants. In late summer/autumn, a second kind of spore is produced that is black/dark brown. These are also spread by wind and can cause additional infections of shoot tips and buds on rooting cane tips. Leaf, shoot tip, and bud infections eventually lead to permanent infection of the entire plant. Newly infected plants seldom show symptoms until the following spring.

**Where is it now?**

*Arthuriomyces peckianus* and *Gymnoconia nitens* are present in Asia, Europe, the United States and Canada.

**How can I protect my farm from Orange rust?**

Source plant material from clean, accredited suppliers and preferably material that is certified. Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common caneberry diseases so you can tell if you see something different.
Raspberry crown borers

What are Raspberry crown borers?
Raspberry crown borers (RCB; Pennisetia marginata and *P. hylaeiformis*) are one of the most devastating pests of raspberry and blackberry crops. Adults are clearwing moths that lay their eggs on the underside edges of leaves in late summer. Hatched larvae burrow into and damage the lower cane, crown (base) and/or roots leading to reduced yield or plant death.

Most commercial and wild Rubus species are affected including red and black raspberry, blackberry, boysenberry, loganberry, salmonberry and thimbleberry.

What do they look like?
Adults resemble yellow jacket wasps and have transparent wings with dark margins and a black fringe. They measure 25 - 30 mm in length with a wingspan of 15 mm. The body is black with four horizontal yellow stripes on the abdomen as well as yellow stripes on the thorax. Legs are yellow and the feathery antennae curve outward from the head.

Eggs are reddish brown and newly emerged larvae are about 3 mm long. Mature larvae are 25 - 38 mm long with a white body, brown head, six short legs on the thorax and pairs of small hooked appendages on abdominal segments. Pupae develop from mature larvae in late summer and are brown and cigar-shaped.

What can they be confused with?
Adults could be confused with yellow jacket wasps, however unlike the noticeable scales on the body and wings of RCB, yellow jackets have no scales and few hairs. Yellow jacket wasps also have short antennae rather than the long curved antennae of RCB.
What should I look for?

Symptoms of RCB infestation include leaf discolouration (prematurely turn red) and stunting, wilting with a shepherd’s crook appearance, spindly cane growth and premature cane death. In spring, look for brittle and hollow canes that may break easily during wind or when tying. Look also for swelling or galls at or below the soil surface and holes/tunnels in the base of canes with sawdust-like frass at the entrance.

How do they spread?

RCB spreads locally by adult flight which occurs over short distances. Long distance spread occurs through the movement of infested plant stock containing larvae.

Where are they now?

*P. marginata* is found throughout North America, Hawaii and in southern parts of Canada. *P. hylaeiformis* is widespread in Europe.

How can I protect my farm from Raspberry crown borers?

Source planting material from ‘clean’, accredited suppliers. Check your farm frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common caneberry pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline

**EXOTIC PLANT PEST HOTLINE**

1800 084 881
Spotted winged drosophila

What is spotted winged drosophila?
The spotted winged drosophila (SWD, *Drosophila suzukii*) is a major horticultural pest affecting many crops particularly soft-skinned fruit including berries (e.g. blueberries), stonefruit and grapes. The larvae of SWD feed internally on host fruit and can cause losses of over 40 per cent in blueberries. In addition to larval feeding, crop losses are also attributed to damage during egg laying (oviposition) and secondary infection of the fruit.

What does it look like?
Adult SWD are small fruit flies 2–3 mm in length with a wingspan of 6–8 mm. They have prominent red eyes and are pale brown or yellow-brown in colour and have dark abdominal bands. The males are generally smaller than females and have a dark spot on the end of each wing. The females can be distinguished under a microscope from other *Drosophila* species by a double serrated ovipositor.

The pupae are found in fruit and the soil, are 1 mm wide, 2–3 mm long and red to brown in colour. They are oval shaped and have a pair of distinctive horn shaped protrusions (respiratory organs), which divide into 7 or 8 branches at one end and a small v-shaped structure at the other (also for respiration). Larvae of SWD are cream to white maggots, approximately 3 mm in length. Eggs of SWD are white, oval shaped, 0.6 mm in length and have two filaments at one end for respiration.

The female can lay eggs in both undamaged ripe and ripening fruit, which is significant as most fruit flies are a pest of either ripe or damaged fruit. Fruit damage consists of pin prick sized holes (stipples) from oviposition, softening, skin wrinkling and tissue collapse from feeding and secondary bacterial and fungal infections.
What can it be confused with?
The larvae and pupae can be confused with other fruit fly larvae and pupae and require an entomologist for further identification. The adults are easily confused with the vinegar fly (Drosophila melanogaster). SWD can be distinguished from other Drosophila species by the dark spots on the wings on males. Fruit damage can also be confused with normal aging of mature fruit particularly skin wrinkling. This species can easily be distinguished from Queensland fruit fly (QFF, Bactrocera tryoni) by the absence of yellow markings and size (QFF adults are 7 mm long, SWD are 2–3 mm long).

What should I look for?
Look for signs of fruit fly damage to fruit including pin prick sized holes, fruit softening, skin wrinkling and secondary infections, on both immature fruit and ripe fruit. Also look for the presence of larvae and pupae within fruit and adult fruit flies on fruit and in traps.

How does it spread?
The adults are capable of flight allowing for localised spread. It is also possible that SWD could be accidently spread on vehicles, machinery or infested plant material (particularly fruit).

Where is it now?
SWD is native to south east Asia but has spread to other parts of Asia, North America and Europe, where it has become a serious pest.

How can I protect my farm from spotted winged drosophila?
Check your crop frequently for the presence of new pests and unusual symptoms. In particular, check your crop for SWD activity such as fruit damage of both immature and ripe fruit. Make sure you are familiar with common blueberry pests so when monitoring your crops for pests you will be alert to the possible presence of exotic pests.
Development stages for blueberry blossom

Figure 8. Tight bud

Figure 9. Bud swell

Figure 10. Bud break

Figure 11. Tight cluster
Development stages for blueberry blossom

Figure 12. Early pink bud
Figure 13. Late pink bud

Figure 14. Full bloom
Figure 15. Petal fall

Figure 16. Green fruit
Figure 17. Fruit colouring
Good management to control common diseases, pests and disorders in blueberries

This guide provides orchardists with suggestions for managing their major pests and diseases through responsibly Managing your legal responsibilities in applying pesticides on page 71.

Pesticide use can be moderated even further through good orchard management. Weather influences the pests and diseases that will affect fruit orchards. By observing the weather, fruit growers can predict the occurrence and severity of pest and disease outbreaks and only spray when a threat exists. Watching the weather and knowing your pests is the key.

There are a number of other ways to reduce the risk posed by a broad range of pests and diseases. Pruning opens tree canopies to allow better spray penetration. Pruning also improves air flow and allows leaves to dry more quickly, reducing the threat from many diseases. Tunnels can be another measure used to reduce leaf wetness, as wetness is reduced under shelter. Unless the reasons are compelling, overhead irrigation should not be used.

Good hygiene, including appropriately removing and disposing of unwanted fruit and diseased plant material, also reduces the threat posed by many insect pests and diseases.

The following section provides specific details on weather conducive to disease or pest outbreaks and on non-pesticide management options. Orchardists should always keep in mind that exclusively using pesticides or alternative management will rarely produce satisfactory fruit quality. Each management strategy complements the other.

Diseases

Anthracnose

Anthracnose is caused by the fungi Colletotrichum acutatum or Colletotrichum gloeosporioides. The pathogen overwinters on infected twigs; old fruiting spurs; live buds; and infected prunings and fruit left in the field. 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.

Local spread of the pathogens is mainly via spores produced on the surfaces of infected plants by rain splash, dewdrop, irrigation water, or via human, insect or bird contact, or shared use of contaminated implements. Longer distance dispersal is achieved by movement of contaminated harvesting equipment (e.g. machinery, packing cases and trays), infected fruit and plants, as well as vehicle and human movement (e.g. berry pickers) between farms. It is important that harvest equipment is cleaned thoroughly between infected and uninfected fields.

After fruit is infected, the fungus remains relatively inactive until berries ripen. Infected areas become sunken and the skin shrivels – under wet conditions masses of sticky salmon coloured spores form on infected fruit. The sunken lesions and salmon–orange coloured spore masses are characteristic of Anthracnose (Figure 18).

Controlling Anthracnose requires fungicide application in response to weather that is conducive to the disease. Regular pruning allows air circulation in the canopy and reduces risk. As the fungus overwinters on infected twigs, removing all dead twigs, fruit and prunings from the field is essential.

[Figure 18. Orange coloured spore masses are characteristic of Anthracnose]
Botrytis

The fungus *Botrytis cinerea* overwinters in infected stems of bushes and in plant debris at the soil line. Vast numbers of spores are produced on these tissues during cool, wet periods. Spores are spread primarily by wind, but can also be spread by splashing water. Moderate temperatures and frequent rains favour disease development.

Blossoms are the most susceptible tissue; infected blossoms turn brown (Figure 20) after a few days of high relative humidity. Under continued humid conditions, masses of grey mycelium and spores are produced on blighted blossoms. Developing berries also become infected (Figure 21), but few rot in the field before harvest.

Control is currently based on minimising conditions favourable for infection and disease development, and on chemical protection. Prune plants annually to keep the canopy open to improve air circulation; this will help speed drying when the plant has become wet from dew or rain. Apply effective fungicides early before flower buds open, ensuring that fungicides that damage flowers are used early before full bloom. Cool berries rapidly after harvest and use sulfur pads in stacked trays. Avoid excessive use of nitrogen fertiliser in the spring, because the Botrytis fungus will readily infect succulent green growth.

Blueberry rust

Blueberry rust is caused by the fungus *Thekospora minima*. Initial symptoms appear as reddish spots on the upper surfaces of young leaves. These lesions darken with age, often surrounded by a yellow halo, which can merge as the disease progresses (Figure 22). On the undersides of the leaves, yellow pustules develop (Figure 23) to release spores capable of infecting other leaves and spreading the disease.

In severe cases, leaves can turn brown and drop prematurely. This defoliation reduces plant vigour and, in the following year, crop yield. Serious defoliation can lead to susceptible cultivars dying.

New pustules can develop and release spores every 10–14 days, with more rapid spore production occurring under favourable climatic conditions – rust is favoured by warm weather with periods of rain and heavy dews. Spring through to autumn is the best time to check plants for signs of blueberry rust and should be checked regularly during this period, especially when conditions are conducive.

The spores released from the pustules are very easily and quickly transported by wind (up to several hundred metres), but can also be spread via rain, infected plants and fruit, packaging, equipment, clothing and hands. It is therefore critical that diligent hygiene practices are implemented to minimise the spread of rust.

Controlling rust requires fungicide application in response to weather that is conducive to the disease. In the north, begin applying protectant fungicides in December. Once the disease is observed it is difficult to control. Rust mostly affects older leaves so its initial effects in the north are during spring and summer and in the south after February. Where possible, orchardists should remove all diseased wood and leaves during pruning and dispose of all fallen and pruned leaves from branches.
Figure 22. Blueberry leaves infected with rust

Figure 23. Yellow pustules

**Downy mildew**

Downy mildew, caused by the fungus *Plasmopara viticola*, appears as yellow–white patches on the upper surfaces of older leaves. On the underside, these areas are covered with white–greyish cotton-like fungi (Figure 24). As these spots age naturally, after a sporulation event or hot weather, their centres dry out and become a reddish brown, leaving an outer ring of yellow. These masses are most often noticed after rain or heavy dew. Fungal spores can be carried by insects, wind, and rain, or by farm workers and equipment. Eliminating moisture and humidity around the plants by pruning to encourage air movement to help dry out leaves and improve sunlight and spray penetration, helps to control the fungus.

Figure 24. White cotton-like fungi that is characteristic of downy mildew

**Phytophthora root rot**

*Phytophthora* spp. are fungus-like (oomycete) soil-borne organisms that require moisture for reproduction and spread. The pathogen attacks the fine-feeder roots of susceptible plants, compromising water and nutrient uptake. The first symptoms observed are often above ground, resembling those of drought or water loss (Figure 25). Fine roots on affected plants become brown and rot. Early foliage symptoms are yellowing leaves. As the disease advances there may be stunting of terminal growth, necrosis of leaves and dieback of the affected plant (Figure 25). Below-ground symptoms include slight necrosis of young rootlets and crowns and main roots turning reddish brown. Bushes can eventually die (Figure 26). Disease symptoms might follow the drainage line as the pathogen can spread by water. Abundant soil moisture and temperatures between 20–32 °C promote disease development. The best control strategy involves prevention. Source new planting material from Phytophthora-free nurseries. In heavy soils or in high rainfall areas blueberries should be grown on mounds with good drainage in the interrow. In high rainfall areas, blueberry mounds run up and down the slope rather than across the contours, for quick drainage. Prepare new sites by mounding and improving soil organic matter; improving soil organic matter and microbial activity can suppress Phytophthora. Avoid planting in poorly drained sites or improve drainage. Grow rooted cuttings or nursery plants on raised beds and avoid over irrigating and ponding.
Good management to control common diseases, pests and disorders

**Septoria leaf spot**

The septoria leaf spot fungus, *Septoria albopunctata*, overwinters on leaves and stems infected during the previous season.

Leaf infections are first visible on the lower leaves as small water-soaked blisters on the bottom side of the leaf. On the upper leaf surface, infected areas develop diffuse red margins (Figure 27). Infected leaves gradually turn yellowish and significant leaf drop can occur. This leaf disease develops under similar environmental conditions that favour Botrytis, rust and Anthracnose.

**Stem blight**

Stem blight (*Neofusicoccum parvum*) is most commonly found in rainy, hot climates. The fungus overwinters in dead and dying canes. Spores are carried by wind or rain from infected wood throughout most of the year. The disease enters young canes through wounds and results in cane death and eventually the entire bush. Young plants are the most susceptible. It begins as a sudden wilt down of leaves on individual branches and travels downwards until eventually the whole cane is dead.

An infected stem if cut longitudinally will show a light brown discolouration under the bark. Prompt removal of diseased canes 15–20 cm below any sign of diseased wood is the most effective method of reducing the spread of the disease. In general fungicides are ineffective.
underground stems of young plants while adults often kill growing points so that the central shoots wither and the plants become dead hearted. Chemical control should aim at preventing larvae feeding on young plants; chemicals should be applied at planting and before root flushes each year.

**Pests**

**African black beetle (Heteronychus arator)**

Newly hatched larvae are about 5 mm long with six legs, white bodies and pale brown heads (Figure 30). Fully grown larvae are 25–30 mm long with a creamy white body and light brown head. The rear end has a dark grey tinge; when resting the grubs curl into a C‑shape. The adult beetle is a rich chestnut colour when newly emerged but changes to a shiny black, stout bodied beetle approximately 10 – 15mm long (Figure 31). Risk periods include summer and early autumn with dry springs and summers favouring a build-up in numbers. Most damage is caused by larvae feeding on the

**Aphids**

Aphids can cause 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. This makes the leaves and fruit sticky, sensitises plant tissue to sunburn and promotes the growth of sooty mould.

Sample for aphids on areas of the bush with tender tissue. These areas include new branch growth and buds and shoots. Be sure to inspect both sides of the leaves and look into leaf curls.

Encourage natural enemies such as predators and parasitoids of aphids by cultivating a progression of flowering plants within or near the blueberry planting. Predators and parasites are attracted to the pollen and nectar of plants in bloom.

Regulate nitrogen fertilisers for optimum, but not excessive, growth and vigour. Aphid populations increase rapidly on most plants receiving excess nitrogen.

Prune if needed to remove suckers and excess growth that enhance the rapid increase of aphid populations. If insecticides are necessary, coverage of lower shoots is essential for optimal aphid control.
Good management to control common diseases, pests and disorders

Figure 32. Aphids on blueberries

Budworms (Helicoverpa)
The native budworm has the capacity to migrate at high altitudes over larger distances (100–1000 km) each night. The moths (Figure 33) 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 cropping regions during early spring. The adults rest during the day and become active after sunset, feeding on nectar from flowers and laying eggs on plants. After hatching the larvae crawl around the plant feeding from plant surfaces particularly tender tissues such as new leaves, fruit and flowers. Chemical control is effective once the pest is seen.

Natural enemies include the tachinid flies and the Trichogamma ivalae, a minute wasp.

Figure 33. Native budworm moth

Dried fruit beetles (Carpophilus beetles)
Carpophilus beetles are small (2–3 mm long) and long black or brown with a narrow, fattened oval shape (Figure 34). A distinguishing factor is that their wing covers are short and do not cover the last two to three segments of the abdomen. The larvae are yellowish and are 5 mm long when fully grown, with a brown head and forked tail.

Carpophilus adults are mechanical carriers of brown rot and Botrytis, transmitting spores as they move across the fruit, which then develops at the sites of beetle damage. Non pesticide management is best achieved by weekly monitoring when berries are ripening, orchard hygiene and good fruit fly control. Controlling this small pest is a numbers game. Using attract and kill traps will reduce populations, but they need to be placed up-wind on the outside edge of the orchard to spread the pheromone attractant throughout the orchard. Traps need to be emptied regularly. Carphophilus beetles should not be confused with Stethorus beetles. Stethorus beetles are an important predator of thrips and mites. They are brown or black like the Carphophilus beetle, but are smaller and almost hemispherical.

Figure 34. Adult carpophilus beetle

Elephant weevil (Orthorhinus cylindrirostris)
The weevil’s body is densely covered with scales that can vary from grey to black (Figure 35). The larva is soft, fleshy, creamy yellow and legless and reaches a length of nearly 20 mm.

Most beetles emerge during September, October and November. There are a number of overlapping generations that emerge from large 5 mm diameter holes in the lower trunk and feed on the young bark of the blueberry plant. The emergent adults climb onto upper branches, usually a few weeks after pruning, and mate. 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. It is the larval stage that causes the most economic damage. Large holes at the base of the plant (Figure 37) are emergence holes when the larvae exits the plant and becomes a mature adult. Control is best achieved when the adults emerge and climb on upper branches of recently pruned plants. There may be some attraction to the pruned plants. Some varieties (MBO 11-11, Star, Costa cv 42) are more attractive than others and so monitoring these varieties is essential for good overall control.
Leafhoppers (Jassids)

Leafhoppers are small, leaf feeding insects ranging from green through to yellow. Predatory bugs and spiders will attack leafhoppers. Unnecessary sprays for leafhoppers will adversely affect these and other beneficial insects.

Light brown apple moth (*Epiphyas postvittana*)

Light brown apple moth (LBAM) is a native Australian leaf-roller (Figure 39). The moths are pale brown with a wing span of about 10 mm (Figure 40). 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. LBAM do not survive well at high temperatures and is therefore a more serious problem in cooler areas with mild summers. Thorough thinning of fruit reduces the number of sheltered sites where this pest can spin webs and pupate. The insect uses weeds such as dock, capeweed and mallow to survive during the winter. Reducing the number of these weeds in your orchard before budswell reduces the overwintering population. Pheromone (Isomate) wire ties placed in the orchard are effective non-chemical mating disruptors against LBAM males (500/ha). Natural enemies such as wasps, lacewings, spiders and predatory shield bugs contribute to overall biological control of LBAM.
Good management to control common diseases, pests and disorders

**Figure 40. LBAM adult**

**Figure 41. Fruit damage due to LBAM**

**Figure 42. Bud mite damage**

**Figure 43. Adult mites, nymphs and eggs**

**Mites (Acalitus vaccinii)**

The blueberry bud mite is a tiny arthropod that lives and feeds inside the fruit buds of blueberries. It is translucent with a soft spindle-shaped body at maturity. The adults are only 0.2 mm long and are not visible to the naked eye. The blueberry bud mite feeds on the bud scales, and on the leaf and floral parts within the blueberry bud. Distinctive red blisters develop on injured tissues within a few weeks of infestation and continued feeding can eventually kill the entire bud. Persistent feeding by large mite populations can result in extensively reduced fruiting potential.

Selectively pruning out old canes will help to reduce bud mite populations in established plantings. Chemical control with registered insecticides needs good coverage and to be applied before mites penetrate too deeply into the buds.

**Redshouldered leaf beetle (Monolepta australis)**

The beetles are 6 mm long and yellow, with a dark red band across the shoulders and two purple spots on the ends of the wing covers (Figure 44).

The flaccid 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.

Adult beetles attack leaves, fruit and flowers, high populations will shred leaves and strip plants of flowers (Figure 45a). Infestations are likely after heavy rainfall (20–40 mm) in spring and summer. They enter orchards from prevailing winds and collect on a few plants before dispersing. Effective control can be achieved if these incursions are discovered and sprayed before they disperse to the rest of the orchard.
Orange fruit borer

The orange fruit borer (*Isotenes miserana*) has recently been discovered in blueberry orchards. The adult moths are light grey, bell-shaped at rest and speckled with small brown marks. The adult lays scale-like eggs in a cluster under leaves. Larvae have a dark brown head and a pair of brown stripes along the body. They pupate within the silken shelter formed while feeding. The pupae are brown or green brown and found on the foliage. On hatching the young larvae feeds on the leaves of infected plant and soon constructs a silken webbed shelter. The life cycle takes 4–6 weeks and successive generations occur throughout the year. In blueberries, the larvae cause the most damage by feeding on young leaves and buds.

Plague thrips

Plague thrips cause damage to flowers by sucking on flower parts and can lead to flower abortion. They are slender insects up to 1 mm long (Figure 48) and are best detected by shaking flowers upside-down over a sheet of paper or onto ones hand. If more than five are detected in 10 flowers then treatment is necessary. Careful management of orchard weeds is required during the critical periods of blossom and in the lead up to fruit maturity. Lacewing larvae and ladybird beetles prey on thrips.
**Painted apple moth (hairy caterpillar)**

Painted apple moth larva is up to 30 mm long and is covered with brown hairs on its back (Figure 49). These larvae chew on tender young leaves. Handling these pests can sometimes cause allergies resulting from the fine hairs on the insect’s back which can irritate the skin.

![Figure 49. Hairy caterpillar](image)

**Queensland fruit fly**

Adult Queensland fruit flies (QFF) are about 6–8 mm long and are coloured reddish brown with yellow markings (Figure 50). They are most active in warm, humid conditions and after rain. QFF lay eggs in maturing and ripe fruit on trees and sometimes in fallen fruit. The maggots (larvae) hatch, then their feeding and the associated decay destroys the fruit. The female fruit fly must feed on a source of protein before her eggs will mature.

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

![Figure 50. Queensland fruit fly](image)

**Scale (wax) insects**

Scale are insects that secrete honeydew and feed on plant tissue. Small infestations are easily controlled by annually pruning old wood. Pruning old, weak canes and scale-infested wood prevents scales from increasing and removes a large pool of eggs. Larger infestations require spraying with petroleum oil before bud break. If left uncontrolled, scale can weaken the blueberry bush and predispose it to disease or abiotic problems. The white wax is seen around autumn each year when the adults settle, so growers should treat plants before this time when the insects are crawlers.

![Figure 51. Scale on blueberry bush](image)

**Scarab beetle**

The scarab larvae (Figure 52) feed on blueberry bush roots. The resulting damage kills or severely reduces the plant’s performance. Scarabs (Figure 53) move into mounds from the surrounding inter row grassed areas, often during dry periods where mounds are being regularly irrigated. This mainly occurs in blueberries in early spring and autumn. The damage they cause is often difficult to diagnose other than seeing the plant has some form of stress to its below ground parts.

![Figure 52. Scarab beetle larva](image)
Slugs and snails

Slugs and snails can cause damage to blueberries. Control begins with rigorous weed control. If they persist, slug and snail killer can be spread on the ground under the crop; refer to the orchard calendar for the registered chemical product.

Spider (red) mites

Both nymphs and adults (Figure 55) damage plant foliage by piercing the cells and sucking the contents, causing the cells to collapse and die.

Red spider mite is more likely to be a problem under warm to hot, dry summer conditions when a life cycle can be completed in just one week. In cooler areas, feeding stops in autumn with the fall in temperatures. In warmer coastal areas, the mite can continue to live and feed throughout the winter on weeds and legumes such as clovers, then reinfest new growth. Plants near dust sources such as dirt roads are particularly susceptible to mite attack.

Using broad spectrum insecticides greatly reduces the number and effectiveness of beneficial insects. If chemical control is required, it is important to carefully select a miticide. Two-spotted mite has been successfully controlled by using an integrated approach in which chemicals are used in combination with the introduced predatory mite *Typhiodromus occidentalis*. These predatory mites are susceptible to different pesticides and growers are advised to obtain a list of pesticides toxic to the predators.

Western flower thrip (WFT)

Western flower thrip (*Frankliniella occidentalis*) eggs are laid in slits made in leaves and growing points. There are two larval stages as well as a pre-pupal and pupal stage. Nymphs and adults (Figure 56) feed in growing points and inside flowers. The life cycle can be completed in as little as 10 days at 20 °C. Populations decline when temperatures exceed 30 °C or fall below 15 °C. Symptoms of feeding include discoloration and indentation of the leaf surface, and damage to buds and flowers, which can result in fallen fruit.

Western flower thrip can blow into properties during hot northerly and westerly winds around October. Properties that have blueberries flowering at this time need diligent monitoring of thrips at this time; thrips are best detected by shaking flowers upside-down over a sheet of paper.

Controlling established WFT populations requires timely pesticide application. However, a number of management practices will reduce pest numbers and minimise damage. As broad leaved weeds (particularly clover) are an alternative WFT host, keep ground covers mown short throughout the year to prevent weeds flowering. Choose pesticides that are less harmful to beneficial insects to encourage their presence and survival.
**Nutrient disorders**

**Phosphorus deficiency**

When phosphorus deficiency occurs, plants can become stunted with small leaves tinted dark green to purple, particularly on the tips and margins. Leaves might lie unusually flat against the stems and twigs, are narrow and can be reddish-purple. Leaves are also small and rounded.

![Symptoms of phosphorus deficiency](image)

**Boron deficiency**

Boron is a common deficiency for blueberries on mounded soils, as it is required by plants in very small amounts and is used up the quickest. Beware of applying too much as toxicity can also be a problem. The rule is: small amounts often. Boron most readily affects growing tips and flowers as the plant cannot pull enough from the soil. Foliar fertilisers such as Solubor® can help reduce this problem.

![Symptoms of boron deficiency](image)

**Copper deficiency**

Copper deficiency in plants can lead to dead shoot tips in rapidly growing plants. This typical ‘goose neck’ is evidence of copper deficiency. Copper deficiency can be easily eliminated by applying at least one copper fungicide spray during the growing season.

![Symptoms of copper deficiency](image)

**Potassium (K) deficiency**

Symptoms of K deficiency can include tip dieback of shoots, scorching along the leaf margins, leaf cupping or curling, and necrotic spots. Symptoms are similar to those caused by drought stress. It is very rare on most north coast soils, but some of the red soils tie up large quantities of K. This can be easily corrected with regular foliar applications of mono-potassium phosphate during winter in the north.

![Symptoms of potassium deficiency](image)

**Magnesium deficiency**

A distinctive pattern of chlorosis develops between the main veins of leaves. These regions can turn yellow to bright red while tissues beside the main veins remain green. Older leaves at the bases of canes and shoots show symptoms first. Young leaves at the tips of shoots are rarely affected.

![Symptoms of magnesium deficiency](image)
Iron-induced chlorosis
Iron chlorosis is common when soil pH is above 5.5. High pH prevents the plants from using iron (Fe) normally. Symptoms appear first at the shoot tips on young leaves. Tissue between veins is a light yellow or bronze-gold colour, 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 poorly drained or compacted. These symptoms usually show up if large quantities of calcium are applied pushing the soil pH up. Can be corrected and verified by a foliar spray of iron chelates which will change leaf colour within a few days if it is indeed iron deficiency.

Figure 62. Symptoms of iron deficiency

Fertiliser root burn
Fertiliser root burn can occur when young plants are planted onto a bed of fertiliser laid into the planting hole. It is important to mix your fertiliser with soil in the hole before you plant. The fertiliser becomes soluble at the bottom of the hole from excessive watering or high rainfall events.

Figure 63. Symptoms of fertiliser root burn

Two-year-old branch changing to three-year-old wood
This is sometimes mistaken for disease or insect damage. The two-year-old red or green wood begins to harden and change to older, mature grey or brown wood.

Figure 64. Two-year-old branch changing to three-year-old wood

Borer damage
There are many pests that can kill healthy blueberry plants. Generally, it is rare for a pest or disease to kill a plant outright, especially if there are no visible culprits. It is more the case that it is a root problem or an internal parasite. In this case, the larvae chews into the plant crown, destroying the internal healthy branch or plant. Prevention next season is the only cure for this problem. Sometimes it is caused by termites on farms beside native timber stands, elephant weevil borer or scarab larvae in soils.

Figure 65. Borer damage to blueberry plant

Frost injury
Blueberries can withstand mild frosts, but it is the length of time and the height of the frost above the ground that are the critical elements for fruit damage. In frost-prone areas of Queensland and NSW, where early Southern Highbush production is required, frost fans are the only reliable insurance against these frost events. Some growers use overhead watering to reduce the effects of mild frost on fruit and flowers, but these cannot be used for long periods as pooling water can exacerbate the frost effects.
Rain damage splitting

Berry splitting is a result of too much rainfall in a very short time. The split runs around the ‘equator’ of the berry. Common in NSW and Qld in summer when 50 mm or more rain falls in a very short period. The only thing growers can do to reduce these effects is to irrigate regularly and top up the soil profile to reduce the surging effect of rainfall moving into the plant from a heavy downpour.

Oedema

Oedema is a disorder that occurs when the roots take up more water than can be used by the plant or the leaves can transpire. This excess water uptake ruptures the cells, particularly on the underside of leaves. Symptoms of oedema are seen as water-soaked spots that become raised, warty or pimple-like swellings or growths. The growths can rupture and can become rust coloured and appear as scaly patches, sometimes being confused with other diseases such as blueberry rust. The main causes of oedema include excessively moist conditions either in the growing medium or atmosphere, and can occasionally occur as a reaction to some fungicides and insecticides. If plants show signs of oedema, check soil condition for waterlogging or flooding.
This section of the guide contains information directly related to management of pests and diseases of blueberries. Most pests and diseases of blueberries appear during specific growth stages of the crop. This guide lists the most common pests and diseases that growers should be on the lookout for over a typical growing season.

This section has been split up into Southern Highbush (Early) and Northern Highbush (Late) for appropriateness and easy adoption for all blueberry growing areas in Australia. The Southern Highbush (Early) section is intended for blueberry growers located in northern NSW and Queensland, where the Northern Highbush (Late) section is intended for blueberry growers located in the southern parts of Australia.

Pest and disease management

Not all pesticides registered for a particular condition are necessarily mentioned. Each group of chemicals is intended to show those compounds recommended for that situation. The list is not in order of effectiveness. Recommendations are intended to be consistent with the registered labels or permit of products. If there is a difference, follow the directions on the label.

No information on rates (quantity of product in the spray mix) is given in the guide. This information appears on the product label. Check the product label for specific instructions and warnings.

Use of chemical names

The information given in the following pages is intended as a guide for blueberry growers and sometimes it is necessarily general. Use of chemical names (active ingredients) in the recommendations is to simplify the entries. Such use implies that at least one product (trade name) containing that chemical is registered for that use. However, it should not be assumed that all products containing that active ingredient are registered for the same use. It is the pesticide user’s responsibility to check the label of the product to be used to ensure that the proposed use is legal and that all directions (rates, timing, warnings, etc.) are complied with.

Products registered for a particular use pattern can be searched on the APVMA portal at www.apvma.gov.au

Guide to chemical groups

The letter in brackets which appears after a chemical name (e.g. copper hydroxide (M1)) refers to its mode of action (MOA) chemical group. This is to help guide users to quickly identify chemical groups for the purpose of resistance management (see Avoiding resistance to pesticides (pages 53–54)).

Resistance management

A fundamental aspect of any integrated pest disease management (IPDM) strategy is the pesticide or pesticides that are used. The primary consideration is to rotate chemicals so that the pest, disease or weed is not continually exposed to the same MOA group. To do this successfully, growers need to be able to identify chemical groups. You can do this by checking the activity group identification symbol, which all registered pesticides have on their labels, e.g. 18, 11, 18.

Colour coding of pesticides

Trade names (in brackets) are only included where only one product is registered for that common name. Coloured dots before the chemical common name denote that chemical’s compatibility with IPM.

1 indicates that – when used with care – a chemical will have very little impact on beneficials and is recommended in an IPDM program.

2 indicates that this pesticide can be used with caution in an IPDM program, but the beneficials present and the chemical’s likely impact should be assessed before application.

3 indicates that this chemical is likely to have a long-lasting, negative off-target effect (including on beneficial arthropods) and it should only be used in an emergency where no alternative exists.
Table 2. Blueberries – calendar Southern Highbush (early)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracnose</td>
<td>Captain PER13958 OR</td>
<td>M4</td>
<td>1</td>
<td>Botrytis control sprays will also control Anthracnose. If rain is forecast and fruit is present apply additional sprays. Captan is preferable close to harvest due to its short WHP. Do not spray more than two consecutive sprays from the same chemical group.</td>
</tr>
<tr>
<td></td>
<td>Cypresdinil + Fludioxonil Switch PER13630 OR</td>
<td>9,12 7 (Aust. only)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boscalid + Pyroclostrubin (Pristine) PER13629 OR</td>
<td>7,11 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copper PER14132 (Qld only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aphids</td>
<td>Pirimicarb OR</td>
<td>1A</td>
<td>2</td>
<td>Do not spray mineral oils if leaf temperatures are 26°C or greater.</td>
</tr>
<tr>
<td></td>
<td>Horticultural mineral oil</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Blueberry rust</td>
<td>Chlorothalonil PER14309 OR</td>
<td>M5</td>
<td>28</td>
<td>Apply at the first sign of rust to leaves, flowers or fruit, beginning in December.</td>
</tr>
<tr>
<td></td>
<td>Propiconazole (Tilt) PER14740 OR</td>
<td>3</td>
<td>3</td>
<td>Use preventatively when conditions favour the disease.</td>
</tr>
<tr>
<td></td>
<td>Mancozeb PER13958 OR</td>
<td>M3</td>
<td>7</td>
<td>If sending fruit with ICA31, apply Pristine or Propiconazole or Dithane every 14 days from fruit set to harvest.</td>
</tr>
<tr>
<td></td>
<td>Boscalid + Pyroclostrubin (Pristine) PER13629 OR</td>
<td>7,11 3</td>
<td></td>
<td>Additional sprays might be required to retain leaves where the disease is a problem.</td>
</tr>
<tr>
<td>Botrytis flower blight Grey mould</td>
<td>Chlorothalonil PER14309 OR</td>
<td>M5</td>
<td>28</td>
<td>Apply at early bloom or before flowers open. Additional sprays might be necessary if conditions favour the disease.</td>
</tr>
<tr>
<td></td>
<td>Pyresidinil (Scala) PER13958 OR</td>
<td>9</td>
<td>1</td>
<td>Scal at full strength will burn flowers and needs to be used before the early pink bud stage.</td>
</tr>
<tr>
<td></td>
<td>Captain PER13958 OR</td>
<td>M4</td>
<td>1</td>
<td>Do not spray more than two consecutive sprays from the same chemical group.</td>
</tr>
<tr>
<td></td>
<td>Switch PER13630 OR</td>
<td>9,12 7</td>
<td>7</td>
<td>Ippon Aquaflo 500 is registered for use in all states.</td>
</tr>
<tr>
<td></td>
<td>Iprodione OR</td>
<td>B</td>
<td>1</td>
<td>Apply every 10–14 days from flowering in rotation with products from other chemical groups.</td>
</tr>
<tr>
<td></td>
<td>Sulphur dioxide pads PER13955</td>
<td>M</td>
<td>1</td>
<td>Sulphur pads are used in packed trays to reduce the incidence of Botrytis.</td>
</tr>
<tr>
<td>Budworms (Heliothis, Helicoverpa)</td>
<td>Spinosad OR</td>
<td>5A</td>
<td>1</td>
<td>Apply when there is evidence of chewing on leaves.</td>
</tr>
<tr>
<td></td>
<td>Spinetoram OR</td>
<td>G5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methomyl PER14134</td>
<td>A1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Methomyl is registered on label for blueberries in NSW and WA but a permit is required for Qld)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downy mildew</td>
<td>Mancozeb PER13958 OR</td>
<td>3</td>
<td>7</td>
<td>Repeat every 14 days.</td>
</tr>
<tr>
<td></td>
<td>Chlorothalonil PER14309 OR</td>
<td>M5</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Elephant weevil borer</td>
<td>Bifenthrin PER14448 OR</td>
<td>3A</td>
<td>1</td>
<td>Spray one week after pruning early SH varieties if weevil is observed on tops of plants. Follow up spray 7–10 days later for later emerging beetles is required.</td>
</tr>
<tr>
<td></td>
<td>Indoxacarb PER13289</td>
<td>22A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Light brown apple moth (LBAM)</td>
<td>Spinetoram OR</td>
<td>G5</td>
<td>1</td>
<td>Isomate mating disruption lures are used in the orchard at 500/ha to confuse LBAM males. Delta traps can be used to monitor numbers. The insect is present when young leaves show folding and webbing is observed around terminal clusters. Do not apply Indoxacarb if bees are foraging.</td>
</tr>
<tr>
<td></td>
<td>Spinosad OR</td>
<td>SA</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methoxyfenozide (Prodigy) OR</td>
<td>G1B</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoxacarb PER13289 OR</td>
<td>22A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Azinphos methyl OR</td>
<td>1B</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacillus thuringiensis</td>
<td>11</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>Monolepta beetle (red shouldered leaf beetle)</td>
<td>Methomyl PER14134</td>
<td>A1</td>
<td>5</td>
<td>Apply to plants when swarm is present. Hatching occurs from grassed rows in spring to autumn after rains. Early detection is essential as swarms can strip leaves, fruit and buds and numbers increase quickly. Ensure adequate spray coverage and penetration to obtain effective control of the pest. Minimum re-treatment interval of 1–2 days.</td>
</tr>
<tr>
<td></td>
<td>(Methomyl is registered on label for blueberries in NSW and WA but a permit is required for Qld) OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyretin PER80070</td>
<td>3A</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>Reason</td>
<td>Treatment</td>
<td>Fungicide group</td>
<td>WHP days</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>-----------------</td>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>Painted apple moth larvae</td>
<td>Yates Nature’s Way Caterpillar Killer Bacillus thuringiensis var. kurstaki is the only control registered in Australia</td>
<td></td>
<td></td>
<td>Apply when chewing damage is first observed. Controls caterpillars on herbs, fruits, vines and ornamentals.</td>
</tr>
<tr>
<td>Phytosphthora root rot</td>
<td>Phosphonic acid (Agrifos, Phospot) <strong>PER13958 OR</strong> Metalaxyl (Ridomil) <strong>PER13958</strong></td>
<td>33</td>
<td>Not required when used as directed 48</td>
<td>Usually caused by poor drainage from the previous season. Plants will show stress signs when fruit flowers and leaves are demanding moisture after a wet year. Metalaxyl should be used when planting and mixed well in the planting hole. Phosphonate can also be used as a root dip when planting.</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>Methomyl <strong>PER14134</strong> (QLD only) <strong>OR</strong> Methomyl (NSW and WA only)</td>
<td>A1</td>
<td>5</td>
<td>Spray during flowering if thrips detected in flowers. Tap 10 flowers on to white paper. If more than four thrips are detected per 10 flowers, treat plants with registered products.</td>
</tr>
<tr>
<td>Queensland fruit fly (QFF)</td>
<td>1. Trapping <strong>OR</strong> 2. Baiting <strong>OR</strong></td>
<td>1B</td>
<td>1</td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings can start in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate <strong>PER13785</strong> or acetoxyl-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications /season. Apply a maximum of three cover sprays/season. Can be used as a cover spray with a maximum of four applications/ season. No more than 12 applications in a season. A grid system of 16 Amulet® <strong>PER13785</strong> fly lures/hectare gives good control in conjunction with monitoring traps, baiting and good crop hygiene.</td>
</tr>
<tr>
<td>Scarab beetles</td>
<td>Chlorpyrifos <strong>PER82002 OR</strong> Chlorantraniliprole <strong>PER81063</strong> (NSW and TAS only) <strong>OR</strong> Clothianidin (Sumitomo Samurai) <strong>PER81063</strong> (NSW and TAS only) <strong>OR</strong> Imidacloprid <strong>PER12534</strong></td>
<td>1B 28 4A</td>
<td>Not required when used as directed 14 14 Not required when used as directed</td>
<td>Soil-borne insects that chew roots and move into mounds from the grassed inter row. Place pellets in bottom of planting hole and mix in well. Retreat if necessary in autumn and spring.</td>
</tr>
<tr>
<td>Slugs and snails</td>
<td>Methiocarb</td>
<td></td>
<td></td>
<td>Snail bait.</td>
</tr>
<tr>
<td>Western flower thrip (WFT)</td>
<td>Diazinon <strong>OR</strong> Horticultural mineral oil</td>
<td>1B</td>
<td>14</td>
<td>WFT activity is more likely close to harvest than at flowering. Do not confuse WFT with other thrips. Easy to treat early in the year around January as crawlers are small. Once the scale forms a waxy coating, it is more difficult to control. Do not spray petroleum spray oil (PSO) if leaf temperatures are over 26 °C.</td>
</tr>
<tr>
<td>White wax scale</td>
<td>1B 14</td>
<td>Easy to treat early in the year around January as crawlers are small. Once the scale forms a waxy coating, it is more difficult to control. Do not spray petroleum spray oil (PSO) if leaf temperatures are over 26 °C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit set growth and harvest – early Southern Highbush, December to July</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthracnose</td>
<td>Captain <strong>PER13958 OR</strong> Cyprodinil + Fludioxonil (Switch) <strong>PER13630 OR</strong> Boscalid + Pyraclostrobin (Pristine) <strong>PER13629 OR</strong> Copper <strong>PER14132 QLQ only</strong></td>
<td>M4 9,12 7,11</td>
<td>1 7 (Aust. only) 3</td>
<td>Botrytis control sprays will also control Anthracnose. If rain is forecast and fruit is present apply additional sprays. Captain is preferable close to harvest due to short WHP. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Aphids</td>
<td>Pirimicarb <strong>OR</strong> Horticultural mineral oil</td>
<td>A1</td>
<td>2 1</td>
<td>Do not spray mineral oils if leaf temperatures are 26 °C or greater.</td>
</tr>
<tr>
<td>Reason</td>
<td>Treatment</td>
<td>Fungicide group</td>
<td>WHP days</td>
<td>Remarks</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Blueberry rust</td>
<td>Chlorothalonil PER14309 OR Propiconazole (Tilt) PER14740 OR Mancozeb PER13958 OR Boscalid + Pyroclostrobin (Pristine) PER13629</td>
<td>M5, M3, M7, M11</td>
<td>3, 7, 3</td>
<td>Apply at first sign of rust to leaves, flowers, or fruit beginning in February. Use preventatively when conditions favour the disease. If sending fruit with CA31 apply Pristine or Propiconazole or Dithane from fruit set to harvest every 14 days. Additional sprays may be required to retain leaves where the disease is a problem.</td>
</tr>
<tr>
<td>Botrytis</td>
<td>Chlorothalonil PER14309 OR Pyramidethanil (Scala) PER13958 OR Captan PER13958 OR Switch PER13630 OR Iprodion OR Sulphur dioxide pads PER13955</td>
<td>M5, M4, M9, M12, M1</td>
<td>28, 1, 7, 1</td>
<td>Apply at early bloom or before flowers open. Additional sprays may be necessary if conditions favour the disease. Scala at full strength will burn flowers and needs to be used before early pink bud stage. Do not spray more than two consecutive sprays from the same chemical group. Ippon Aquaflo 500 is registered for use in all states. Apply every 10 – 14 days from flowering in rotation with products from other chemical groups. Sulphur pads are used in packed trays to reduce the incidence of Botrytis.</td>
</tr>
<tr>
<td>Budworms (Heliothis, Helicoverpa)</td>
<td>Spinosad OR Spinetoram OR Methomyl PER14134 (Methomyl is registered on label for blueberries in NSW and WA but a permit is required for QLD)</td>
<td>G5, A1</td>
<td>1, 5</td>
<td>Apply when leaves show evidence of chewing.</td>
</tr>
<tr>
<td>Downy mildew</td>
<td>Mancozeb PER13958 OR Chlorothalonil PER14309</td>
<td>M3, M5</td>
<td>7, 28</td>
<td>Repeat every 14 days.</td>
</tr>
<tr>
<td>Elephant weevil borer</td>
<td>Bifenthrin PER14448 OR Indoxacarb PER13289</td>
<td>3A, 22A</td>
<td>1, 1</td>
<td>Spray one week after pruning early SH varieties if weevil is observed on tops of plants. A follow up spray 7 – 10 days later for later emerging beetles is required.</td>
</tr>
<tr>
<td>Light brown apple moth (LBAM)</td>
<td>Spinetoram OR Spinosad OR Methoxyfenozide (Prodigy) OR Indoxacarb PER13289 OR Azinphos methyl OR Bacillus thuringiensis</td>
<td>G5, S5, G18, 22A, 1B, 11</td>
<td>1, 7</td>
<td>Isomate mating disruption lures are used in the orchard at 500/ha to confuse LBAM males. Delta traps can be used to monitor numbers. The insect is present when young leaves show folding and webbing is observed around terminal clusters. Do not apply Indoxacarb if bees are foraging.</td>
</tr>
<tr>
<td>Monolepta beetle (red shouldered leaf beetle)</td>
<td>Methomyl PER14134 (Methomyl is registered on label for blueberries in NSW and WA but a permit is required for QLD) OR Pyrethrin PER80070</td>
<td>A1, 3A</td>
<td>5, 7</td>
<td>Apply to plants when swarm is present. Hatching occurs from grassed rows in spring to autumn after rains. Early detection is essential as swarms can strip leaves, fruit, and buds and numbers increase quickly. Ensure adequate spray coverage and penetration to obtain effective control of the pest. Minimum re-treatment interval of 1-2 days.</td>
</tr>
<tr>
<td>Painted apple moth larvae</td>
<td>Yates Nature’s Way Caterpillar Killer Bacillus thuringiensis var. kurstaki is the only control registered in Australia</td>
<td>Nil</td>
<td>Nil</td>
<td>Apply when chewing damage is first observed. Controls caterpillars on herbs, fruits, vines, and ornamentals.</td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td>Phosphonic acid Agri-fos, Phospot PER13958 OR Metalaxyl (Ridomil) PER13958</td>
<td>33, 4</td>
<td>Not required when used as directed</td>
<td>Usually caused by poor drainage. Plants will show stress signs when fruit flowers and leaves are demanding moisture after a wet year. Metalaxyl should be used when planting and mixed well in the planting hole. Phosphonate can also be used as a root dip at planting.</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>Methomyl PER14134 (QLD only)</td>
<td>A1</td>
<td>5 days</td>
<td>Spray during flowering if Thrips detected in flowers. Tap 10 flowers on to white paper. If more than 4 thrips detected per 10 flowers treat plants with registered products</td>
</tr>
</tbody>
</table>
Table 2. Blueberries – calendar Southern Highbush (early) (continued)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland fruit fly (QFF)</td>
<td>1. Trapping OR</td>
<td>Dimethoate PER13290 OR</td>
<td>1B 1</td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td></td>
<td>2. Baiting OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maldison PER12940 OR</td>
<td>1B 3</td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trichlorfon PER12486 OR</td>
<td>1B 2</td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spinetoram PER12927 OR</td>
<td>5G 1</td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abamectin PER14423</td>
<td>6 7</td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Blueberry rust</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Light brown apple moth (LBAM)</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Monolepta beetle</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Painted apple moth larvae</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Scarab beetle</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>White wax scale</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
</tbody>
</table>

WHP = Withholding period  
SH = Southern Highbush

Table 3. Blueberries – calendar Northern Highbush (late)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post harvest to dormancy – late Northern Highbush February to August</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Anthracnose</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Blueberry rust</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>1. Hang male lures in the orchard (16/ha) to detect fly presence. Fruit stings may commence in August. 2. Start a baiting program both inside the orchard and on perimeter trees before numbers spike in traps. Repeat weekly using yeast autolysate PER13785 or acetoxy-phenyl-butanone (cue-lure) with either maldison, fipronil or spinosad as a contact insecticide. Dimethoate is under permit and can be used for QFF control as a cover spray from flowering to harvest. Apply a maximum of three applications/season. Do not spray more than 2 consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td>Reason</td>
<td>Treatment</td>
<td>Fungicide group</td>
<td>WHP days</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------</td>
<td>-----------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Botrytis Grey mould</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td>Apply at early bloom or before flowers open. Additional sprays may be</td>
<td>Apply at early bloom or before flowers open. Additional sprays may be</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td>necessary if conditions favour the disease.</td>
<td>necessary if conditions favour the disease.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scala at full strength will burn flowers and needs to be used before early</td>
<td>Scala at full strength will burn flowers and needs to be used before early</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pink bud stage.</td>
<td>pink bud stage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Do not spray more than two consecutive sprays from same chemical group.</td>
<td>Do not spray more than two consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Keep shorter WHP products close to harvest if an outbreak occurs at this</td>
<td>Keep shorter WHP products close to harvest if an outbreak occurs at this</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>time or wet weather occurs.</td>
<td>time or wet weather occurs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ippon Aquaflo 500 is registered for use in all states.</td>
<td>Ippon Aquaflo 500 is registered for use in all states.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Apply every 10–14 days from flowering in rotation with products from other</td>
<td>Apply every 10–14 days from flowering in rotation with products from other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>chemical groups.</td>
<td>chemical groups.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sulfur pads are used in packed trays to reduce the incidence of Botrytis</td>
<td>Sulfur pads are used in packed trays to reduce the incidence of Botrytis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>post harvest.</td>
<td>post harvest.</td>
</tr>
<tr>
<td>European wasp</td>
<td>Permethrin dust PER12763</td>
<td></td>
<td>To be used to dust meat baits and place in hanging traps around</td>
<td>Orchard. Replace every 3 days if insect persists.</td>
</tr>
<tr>
<td>Light brown apple</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td>moth (LBAM)</td>
<td>Isomate mating disruption lures are used in the orchard at 500/ha to</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td>Confuse LBAM males.</td>
<td>Confuse LBAM males.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Delta traps can be used to monitor numbers.</td>
<td>Delta traps can be used to monitor numbers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The insect is present when young leaves show folding and webbing is</td>
<td>The insect is present when young leaves show folding and webbing is</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>observed around terminal clusters.</td>
<td>observed around terminal clusters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Do not apply if bees are foraging.</td>
<td>Do not apply if bees are foraging.</td>
</tr>
<tr>
<td>Painted apple moth</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td>larvae</td>
<td>Apply at first sign of chewing damage.</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytophthora root</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td>rot</td>
<td>Usually caused by poor drainage. Plants will show stress signs when</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>fruit flowers and leaves are demanding moisture after a wet year.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Metalaxyl should be used when planting and mixed well in the planting hole.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Phosphonate can also be used as a root dip when planting.</td>
</tr>
<tr>
<td>Dormancy</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Apply if necessary.</td>
</tr>
<tr>
<td>Scale insects</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flowering</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botrytis Grey mould</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td>Apply at early bloom or before flowers open. Additional sprays may be</td>
<td>Apply at early bloom or before flowers open. Additional sprays may be</td>
</tr>
<tr>
<td>February to August</td>
<td></td>
<td></td>
<td>necessary if conditions favour the disease.</td>
<td>necessary if conditions favour the disease.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scala at full strength will burn flowers and needs to be used before early</td>
<td>Scala at full strength will burn flowers and needs to be used before early</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pink bud stage.</td>
<td>pink bud stage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Do not spray more than two consecutive sprays from same chemical group.</td>
<td>Do not spray more than two consecutive sprays from same chemical group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Keep shorter WHP products close to harvest if an outbreak occurs at this</td>
<td>Keep shorter WHP products close to harvest if an outbreak occurs at this</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>time or wet weather occurs.</td>
<td>time or wet weather occurs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ippon Aquaflo 500 is registered for use in all states.</td>
<td>Ippon Aquaflo 500 is registered for use in all states.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Apply every 10–14 days from flowering in rotation with products from other</td>
<td>Apply every 10–14 days from flowering in rotation with products from other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>chemical groups.</td>
<td>chemical groups.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sulfur pads are used in packed trays to reduce the incidence of Botrytis</td>
<td>Sulfur pads are used in packed trays to reduce the incidence of Botrytis.</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Spray during flowering if Thrips detected in flowers.</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>Tap 10 flowers on to white paper. If more than 4 thrips detected per 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>flowers treat plants with registered products.</td>
</tr>
<tr>
<td>Scarab beetles</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Soil-borne insects that chew roots and move into mounds from the</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>grassed interrow.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Place pellets in bottom of planting hole and mix in well.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Retreat if necessary in autumn and spring. Imidacloprion can be applied through the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dripline at a rate of 14 ml/100 m of row length.</td>
</tr>
<tr>
<td>Slugs and snails</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Snail and slug bait.</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western flower thrip</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>WFT activity is more likely close to harvest than at flowering. Do not</td>
</tr>
<tr>
<td>(WFT)</td>
<td>February to August</td>
<td></td>
<td></td>
<td>confuse WFT with other thrips.</td>
</tr>
</tbody>
</table>
Table 3. Blueberries – calendar Northern Highbush (late) (continued)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Treatment</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Apply at first sign of rust to leaves flowers or fruit beginning in</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>December. Use preventative when conditions favour the disease.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>If sending fruit with ICA31 apply Propiconazole Pristine and Dithane</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>from fruit set to harvest every 14 days. Additional sprays may be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>required to retain leaves where the disease is a problem.</td>
</tr>
<tr>
<td>Blueberry rust</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Apply at early bloom or before flowers open. Additional sprays may be</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>necessary if conditions favour the disease.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Scala at full strength will burn flowers and needs to be used before</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>early pink bud stage. Do not spray more than 2 consecutive sprays from</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>same chemical group. Keep shorter WHP products close to harvest if an</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>outbreak occurs at this time or wet weather occurs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ippon Aquaflo 500 is registered for use in all states.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apply every 10–14 days from flowering. In rotation with products from</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>other chemical groups.</td>
</tr>
<tr>
<td>Botrytis</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Isoamate mating disruption lures are used in the orchard at 500/ha to</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>confuse LBAM males. Delta traps can be used to monitor numbers. The</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>insect is present when young leaves show folding and webbing is observed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>around terminal clusters. Do not apply if bees are foraging.</td>
</tr>
<tr>
<td>Light brown apple moth (LBAM)</td>
<td>As per EARLY Southern Highbush</td>
<td></td>
<td></td>
<td>Isomate mating disruption lures are used in the orchard at 500/ha to</td>
</tr>
<tr>
<td></td>
<td>February to August</td>
<td></td>
<td></td>
<td>confuse LBAM males. Delta traps can be used to monitor numbers. The</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>insect is present when young leaves show folding and webbing is observed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>around terminal clusters. Do not apply if bees are foraging.</td>
</tr>
</tbody>
</table>

Table 4. Blueberries Southern Highbush (early) – likely timing for monitoring and treatment of pests as indicated by the purple bars

<table>
<thead>
<tr>
<th>Reason</th>
<th>Flowering</th>
<th>Harvest</th>
<th>Post Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>African black beetle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthracnose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aphids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botrytis flower blight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Budworms (Helicoverpa previously Heliothis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caterpillars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common garden snail</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn earworm (Helicoverpa previously Heliothis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downy mildew</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dried fruit beetles (Carpophilus)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant weevil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey mould (Botrytis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jassids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesser Queensland fruit fly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light brown apple moth (LBAM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loopers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monolepta beetle</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>
</tbody>
</table>
Table 4. Blueberries Northern Highbush (late) – likely timing for monitoring and treatment of pests as indicated by the purple bars (continued)

<table>
<thead>
<tr>
<th></th>
<th>Flowering</th>
<th>Harvest</th>
<th>Post Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>May</td>
<td>June</td>
<td>July</td>
</tr>
<tr>
<td>Painted apple moth (hairy)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland fruit fly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale (wax) insects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scarab beetle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Septoria leaf spot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slugs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spider (red) mites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spur blight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western flower thrip</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Blueberries Southern Highbush (early) – likely timing for monitoring and treatment of pests as indicated by the purple bars (continued)

<table>
<thead>
<tr>
<th></th>
<th>Post harvest</th>
<th>Dormancy</th>
<th>Flowering</th>
<th>Harvest</th>
<th>Post Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>May</td>
<td>June</td>
<td>July</td>
<td>August</td>
<td>September</td>
</tr>
<tr>
<td>Aphids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botrytis flower blight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caterpillars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common garden snail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downy mildew</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European wasp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey mould (botrytis)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light brown apple moth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loopers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland fruit fly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slugs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western flower thrip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Pesticides: chemicals registered/permitted for managing blueberries

<table>
<thead>
<tr>
<th>For managing</th>
<th>Pesticide common name (Trade name)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>African black beetle</strong></td>
<td>Imidacloprid (Confidor®)</td>
<td>Contact and stomach insecticide applied through drippers</td>
</tr>
<tr>
<td><strong>Anthracnose</strong></td>
<td>Captain</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Cyprodinil + fludioxonil (Switch®)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Boscalid + Pyroclorotin (Pristine®)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Copper oxychloride</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td><strong>Aphids</strong></td>
<td>Pirimicarb</td>
<td>Stomach action</td>
</tr>
<tr>
<td></td>
<td>Horticultural mineral oil</td>
<td>Insecticide and miticide</td>
</tr>
<tr>
<td><strong>Botrytis flower blight</strong></td>
<td>Chlorothalonil</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Pyrimethanil (Scala*)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Captan</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Cyprodinil + fludioxonil (Switch®)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Ipodione</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Sulfur dioxide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boscalid + Pyroclorotin (Pristine®)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td><strong>Budworms (Heliothis, Helicoverpa)</strong></td>
<td>Spinosad</td>
<td>Insecticide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>Spinetoram (Delegate*)</td>
<td>Insecticide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>Methomyl</td>
<td>Systemic insecticide with contact and stomach action</td>
</tr>
<tr>
<td><strong>Caterpillars</strong></td>
<td>Bacillus thuringensis</td>
<td>Biological control-stomach poison</td>
</tr>
<tr>
<td><strong>Common garden snail</strong></td>
<td>Methiocarb snail bait</td>
<td>Molluscide acts as a physical barrier</td>
</tr>
<tr>
<td><strong>Corn earworm (Heliothis, Helicoverpa)</strong></td>
<td>Spinosad</td>
<td>Insecticide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>Spinetoram (Delegate*)</td>
<td>Insecticide with contact action</td>
</tr>
<tr>
<td></td>
<td>Methomyl</td>
<td>Systemic insecticide with contact and stomach action</td>
</tr>
<tr>
<td><strong>Downy mildew</strong></td>
<td>Chlorothalonil</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Mancozeb</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td><strong>Dried fruit beetles (Carpophilus)</strong></td>
<td>Carphophilus lure and trap system</td>
<td>Used as lure to attract insects to trap</td>
</tr>
<tr>
<td></td>
<td>Mancozeb</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td><strong>Elephant weevil</strong></td>
<td>Indoxacarb (Avatar®)</td>
<td>Insecticide with both contact and stomach action on larvae</td>
</tr>
<tr>
<td></td>
<td>Maldison</td>
<td>Contact insecticide</td>
</tr>
<tr>
<td><strong>European wasp</strong></td>
<td>Permethrin (bait only)</td>
<td>Contact insecticide for use on dusted baits</td>
</tr>
<tr>
<td><strong>Grey mould (Botrytis)</strong></td>
<td>Chlorothalonil</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Pyrimethanil (Scala*)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Captain</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Cyprodinil + fludioxonil (Switch®)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Ipodione</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Sulfur dioxide infruta pads</td>
<td>Fungicide with vapour action</td>
</tr>
<tr>
<td></td>
<td>Boscalid + Pyroclorotin (Pristine®)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td><strong>Lesser Queensland fruit fly</strong></td>
<td>Dimethoate</td>
<td>Contact insecticide with larvicidal and ovicidal activity</td>
</tr>
<tr>
<td></td>
<td>Maldison</td>
<td>Contact insecticide with stomach and respiratory action</td>
</tr>
<tr>
<td></td>
<td>Trichlorfon</td>
<td>Insecticide and acaricide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>Spinetoram (Delegate*)</td>
<td>Insecticide with contact action</td>
</tr>
<tr>
<td></td>
<td>Abamectin</td>
<td>Acaricide with stomach action and translaminar movement</td>
</tr>
</tbody>
</table>
### Table 6. Pesticides: chemicals registered/permitted\(^1\) for managing blueberries (continued)

<table>
<thead>
<tr>
<th>For managing…</th>
<th>Pesticide common name (Trade name)(^2)</th>
<th>Comment(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light brown apple moth (LBAM)</td>
<td>2 Spinetoram (Delegate(^*))</td>
<td>insecticide with contact action</td>
</tr>
<tr>
<td></td>
<td>2 Spinosad</td>
<td>insecticide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>1 Methoxyfenozide (Prodigy(^*))</td>
<td>insecticide with contact action</td>
</tr>
<tr>
<td></td>
<td>1 Indoxacarb (Avatar(^*))</td>
<td>insecticide with both contact and stomach action on larvae</td>
</tr>
<tr>
<td></td>
<td>3 Azinphos methyl</td>
<td>insecticide with contact and stomach action, moderate persistence</td>
</tr>
<tr>
<td></td>
<td>1 Bacillus thuringiensis</td>
<td>biological control-stomach poison</td>
</tr>
<tr>
<td>Loopers</td>
<td>2 Spinosad</td>
<td>insecticide with contact and stomach action</td>
</tr>
<tr>
<td>Mites</td>
<td>2 Bifenazate Acramite(^*)</td>
<td>acaricide with contact and residual activity</td>
</tr>
<tr>
<td>Monolepta beetle</td>
<td>2 Methomyl</td>
<td>systemic insecticide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>1 Pyrethrin Pyganic(^*)</td>
<td>contact insecticide</td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td>1 Metalaxyl (Ridomil(^*))</td>
<td>protectant fungicide with slow release activity</td>
</tr>
<tr>
<td></td>
<td>1 Phosphonic acid</td>
<td>protectant fungicide</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>3 Methomyl</td>
<td>systemic insecticide with contact and stomach action</td>
</tr>
<tr>
<td>Painted apple moth (hairy)</td>
<td>1 Bacillus thuringiensis</td>
<td>biological control-stomach poison</td>
</tr>
<tr>
<td>Queensland fruit fly</td>
<td>3 Dimethoate</td>
<td>contact insecticide with larvicidal and ovicidal activity</td>
</tr>
<tr>
<td></td>
<td>3 Malison</td>
<td>contact insecticide with stomach and respiratory action</td>
</tr>
<tr>
<td></td>
<td>3 Trichlorfon</td>
<td>insecticide and acaricide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>2 Spinetoram (Delegate(^*))</td>
<td>insecticide with contact action</td>
</tr>
<tr>
<td></td>
<td>2 Abamectin used in conjunction with protein yeast attractant</td>
<td>contact insecticide with stomach and respiratory action</td>
</tr>
<tr>
<td></td>
<td>1 Aceotoxy-phenyl-butane Amulet lures</td>
<td>contact insecticide impregnated into baits</td>
</tr>
<tr>
<td></td>
<td>1 Fipronil (Amulet cue lure(^*))</td>
<td>contact insecticide impregnated into baits and gel powder in yeast mixture</td>
</tr>
<tr>
<td>Rust</td>
<td>2 Mancozeb</td>
<td>protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>3 Propiconazole (Tilt(^*))</td>
<td>systemic fungicide with protectant and curative action</td>
</tr>
<tr>
<td></td>
<td>1 Boscalid + Pyroclostrobin (Pristine(^*))</td>
<td>fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>2 Chlorothalonil</td>
<td>protectant fungicide</td>
</tr>
<tr>
<td>Scale (wax)</td>
<td>3 Diazinon</td>
<td>insecticide with contact, stomach and respiratory action</td>
</tr>
<tr>
<td></td>
<td>1 Horticultural mineral oil</td>
<td>insecticide and miticide</td>
</tr>
<tr>
<td>Scarab beetles</td>
<td>3 Imidacloprid</td>
<td>systemic insecticide applied by dripper to plant root systems</td>
</tr>
<tr>
<td></td>
<td>2 Chlorpyrifos</td>
<td>contact insecticide with stomach and respiratory action</td>
</tr>
<tr>
<td></td>
<td>1 Chlorantraniliprole</td>
<td>insecticide interrupts normal muscle contraction</td>
</tr>
<tr>
<td>Septoria leaf spot</td>
<td>2 Chlorothalonil</td>
<td>protectant fungicide</td>
</tr>
<tr>
<td>Slugs</td>
<td>3 Copper as complex Kendon Escar-Go(^*)</td>
<td>protectant molluscide</td>
</tr>
<tr>
<td>Spider (red) mites</td>
<td>2 Bifenazate</td>
<td>acaricide with contact and residual activity</td>
</tr>
<tr>
<td>Spur blight</td>
<td>2 Captan</td>
<td>protectant fungicide</td>
</tr>
<tr>
<td>Thrips</td>
<td>3 Methomyl</td>
<td>systemic insecticide with contact and stomach action</td>
</tr>
<tr>
<td></td>
<td>3 Bifenthrin</td>
<td>contact insecticide</td>
</tr>
<tr>
<td>Western flower thrip (WFT)</td>
<td>2 Spinosad</td>
<td>insecticide with contact and stomach action</td>
</tr>
</tbody>
</table>

\(^1\) Source: APVMA Pubcris.

Trade names (in brackets) are only included where only one product is registered for that common name. Coloured dots before the chemical common name denote that chemical’s compatibility with IPM.

\(^2\) indicates that — when used with care — a chemical will have very little impact on beneficials and is recommended in an IPM program.

\(^3\) indicates that this pesticide can be used with caution in an IPM program, but the beneficials present and the chemicals likely impact should be assessed prior to application.

\(^3\) indicates that this chemical is likely to have a long-lasting, negative off-target impact (including an impact on beneficial arthropods) and it should only be used in an emergency where no alternative exists.

Development stages for raspberry blossom

Figure 69. Raspberry bud
Figure 70. Raspberry bloom
Figure 71. Bloom to green fruit
Figure 72. Green fruit
Figure 73. Green to ripe fruit
Good management to control common diseases, pests and disorders in raspberries and blackberries

This guide provides orchardists with suggestions for managing major pests and diseases through the Managing your legal responsibilities in applying pesticides on page 71. Pesticide use can be moderated even further through good orchard management.

Weather influences the pests and diseases that will affect fruit orchards. By observing the weather, fruit growers can predict the occurrence and severity of pest and disease outbreaks and only spray when a threat exists. Watching the weather and knowing your pests and diseases is the key.

There are a number of other ways to reduce the risk that a broad range of pests and diseases poses.

- Pruning opens tree canopies to allow better spray penetration. It also improves air flow and allows leaves to dry more quickly, reducing the threat from many diseases.
- Tunnels can be another measure used to reduce leaf wetness as wetness is reduced under shelter. Unless the reasons are compelling, overhead irrigation should not be used.
- Good hygiene, including appropriately removing and disposing of unwanted fruit and diseased plant material, also reduces insect pest and disease threats.

The following section provides specific details on weather conducive to disease or pest outbreaks, and on non-pesticide management options. Orchardists should always keep in mind that exclusively using pesticides or alternative management will rarely produce satisfactory fruit quality. Each management strategy supplements the other.

**Diseases**

**Anthracnose (cane spot)**

Anthracnose is caused by the fungus *Elsinöe veneta*. Anthracnose, or cane spot, usually affects plant stems, but can also affect the fruit and leaves. Symptoms begin as small, distinct purplish spots appearing on younger stems. The spots increase in size and their centres turn a grey colour, while the outer edge stays purple. In severe cases, the spots join together and cause the stem to become weak and, in some cases, die. On leaves, anthracnose symptoms appear as irregularly shaped, yellow spots. These spots enlarge and develop grey centres with reddish-purple borders, over time these grey centres can fall out giving the spots a shot-hole effect.

![Anthracnose infected leaf](image)

Anthracnose can be introduced by infected plants or by spores that are dispersed by rain or water, blown in the wind or transported on contaminated clothing vehicles or machinery. The pathogen overwinters on infected twigs and leaves. Control of anthracnose begins with clean, disease-free planting material. Promote good air movement by keeping fruit rows narrow, spacing canes adequately and controlling weeds.

**Botrytis**

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

Grey mycelium (fluffy mould) develops on flowers when conditions are cool and moist. Under dry conditions, infected berries turn brown and shrivel. Botrytis can grow into flower tissues causing severe blighting resulting in no fruit formation (Figure 75).
Infected berries develop a grey/brown rot that eventually spreads over the whole fruit, which becomes covered with dry greyish spores. The rot can start on any portion of the fruit, but is most frequently on the calyx end or on the sides of the fruit that touches other rotten fruit. The disease favours cool (15–25 °C), wet conditions and plants should be monitored for signs of Botrytis during these conditions.

Control is currently based on minimising conditions favourable for infection and disease development, and on timely chemical protection. Infection takes place during flowering so chemicals should be applied accordingly. Infected fruit and plant material should be removed from the field to reduce Botrytis spores; each infected fruit has spores on it with the potential to infect more flowers and fruit. Raspberries should be trained to encourage air flow and row bases should be kept clean and narrow. Apply effective fungicides before predicted moisture events such as rain, heavy fog or high humidity. After harvest, cool berries rapidly and use sulphur pads in stacked trays.

Downy mildew, caused by the fungus *Peronospora* spp. overwinters inside roots, crowns and canes. Symptoms consist of a light green to yellow discolouration on the upper leaf surface that progress to red and purple (Figure 77). 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 78). Spore masses are produced only on the lower leaf surface and are initially white, but become light grey with age. Berries infected with downy mildew appear dull. Infected green fruit causes premature reddening and the berries to shrivel and harden. Downy mildew favours warm, humid areas and is most prevalent during wet weather at temperatures of 18–22 °C.

Controlling downy mildew begins by using pathogen-free planting stock. Ensure good airflow through the canopy to maximise spray penetration. 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.
**Phytophthora root rot**

Phytophthora root rot is caused by the soil-borne oomycetes (fungus-like organisms) *Phytophthora rubi* and other Phytophthora species. These soil-borne organisms require moisture for reproduction and spread. The pathogen attacks the fine feeder roots of susceptible plants, compromising water and nutrient uptake. Symptoms of Phytophthora root rot are more apparent during dry, warm weather and often occur in clusters of plants spread along drainage lines. Symptoms are first noticed when new primocanes wilt and shoot tips die back. Floricanes (fruiting canes) of affected plants have weak lateral shoots. Leaves wilt and become yellow or brown from the margins until the entire leaf dies (Figure 79). Symptoms on roots appear as a black to brown discoloured roots (Figure 80) and they lack fine feeder roots. If cut open, the centre of the main root is brown and affected plants are easily pulled from the soil. Phytophthora root rot development is favoured when soil temperatures are greater than 12 °C, when there is poor drainage, water ponding, heavy soils or low levels of organic matter in the soil. Controlling Phytophthora root rot begins with clean, disease-free planting material. Destroy infected plants and prevent soil or water moving from infected areas to clean areas. Prevent soil compaction, which occurs with traffic in wet conditions. Phytophthora is suppressed in conditions of low soil compaction, high levels of organic matter and good biological activity. Avoid moving soil or vehicles when it is wet to reduce soil movement and possible infection spread.

**Powdery mildew**

Powdery mildew on raspberries is caused by the fungus *Podosphaera aphanis*. The fungus overwinters in the dormant buds on stunted cane tips. Raspberry and blackberry leaves infected with powdery mildew initially develop light green (chlorotic) patches on the upper surface. Leaves and shoots are later covered with white to grey mycelial growth (Figure 81). Affected leaves can be curved, twisted, or otherwise distorted. Severely infected shoots become long and spindly, with dwarf leaves that curl upward. Severely diseased plants can be stunted. Flower buds and fruit are also seriously affected; the fungus can prevent late buds from developing into fruit and can render the fruit worthless by completely covering it with white mycelial growth. Infections start on dry leaves in high humidity over 15 °C with optimum conditions being 18–25 °C and over 97% humidity. Visible signs appear four weeks after infection. Raspberries should be monitored when conditions favour the disease. To help control powdery mildew, remove late-forming infected primocanes. Ensure good airflow through the canopy to maximise spray penetration. Prune, train and thin out primocanes early to reduce humidity in the canopy. Manage nutrition and irrigation to avoid a highly vigorous canopy and remove late-forming infected primocanes. Use tip pruning to remove some infection sources before next season.
Raspberry bushy dwarf virus

Raspberry bushy dwarf virus (RBDV) is transmitted by pollen and, therefore, bees and other insects that forage in flowers spread the virus. Symptoms appear as yellow flecks or splashes on leaves (Figure 82) and poor fruit set (Figure 83). These fruit are crumbly when they ripen. The yellow leaf colouration is distinctive rather than the common pale cream–yellow that sucking insects or senescence cause. Infected plants should be destroyed immediately following identification. Virus diseases are incurable in the field and so the only safeguard against virus infection is to begin with clean plants supplied by an approved plant health scheme.

Yellow rust

Yellow rust is caused by the fungus Phragmidium rubi-idaei. The initial symptoms of yellow rust on raspberry leaves and emerging shoots occur from over-wintered spores and appear as raised yellow orange pustules on the upper side of raspberry leaves (Figure 84). Later in the season, orange–yellow spots appear on the underside of leaves (Figure 85), and these turn black as the fungus lifecycle progresses. The yellow rust fungus overwinters on the bark of remaining floricanes, which are the source of inoculum that affects emerging leaves and primocanes the following season. Phragmidium rubi-idaei can defoliate canes if prolonged wet weather in spring encourages rapid development.

Check 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. Leaf wetness, high humidity and mild temperatures (11–25 °C) favour infection. Manage primocane density to maintain an open canopy to increase airflow, reduce humidity and maximise spray penetration. Keep ground cover low to reduce humidity around canes.
**Pests**

**Dried fruit beetle (carphophilus beetle)**

Figure 86.  Figure 13: Adult carphophilus beetle

Carpophilus beetles are small (2–3 mm long), black or brown with a narrow, fattened oval shape (Figure 86). A distinguishing factor is that their wing covers are short and do not cover the last two to three segments of the abdomen. The larvae are yellowish and are 5 mm long when fully grown, with a brown head and forked tail. The carpophilus beetle feeds 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. Non-pesticide management is best achieved by monitoring, orchard hygiene and good fruit fly control. Traps are available from retail rural suppliers and need to be placed up wind on the outside edge of the orchard to spread the pheromone attractant through the orchard. Orchard hygiene can be improved by removing and destroying waste fruit from orchards. Controlling Queensland fruit fly will decrease the amount of fallen fruit.

**Green vegetable bug (Nezara viridula)**

Figure 87.  Adult green vegetable bug

The adult green vegetable bug (GVB) (*Nezara viridula*) is 15 mm long, green, shield shaped and releases a stink when disturbed to deter predators (Figure 87). The nymphal stages look similar to the adult, but with a range of green, yellow and black markings. The adults overwinter on other hosts (i.e. maize crops, wild tobacco etc.), under tree bark or in farm sheds. In warmer coastal areas, GVB will feed and breed all year round. GVBs invade crops at flowering, laying eggs underneath leaves in rafts. Nymphs and adults feed by piercing flower buds and fruitlets. GVB eggs can be parasitised by a tiny introduced wasp *Trissolcus basalis*, and nymphs can be attacked by ants, spiders and predatory bugs where the adult is parasitised by the tachinid fly *Trichopoda giacomelli*.

**Green stink bug (Plautia affinis)**

Adult green stink bugs (*Plautia affinis*) are around 8 mm long and have a green shield shaped body with brown wing covers (Figure 88). Each female lays around 200–300 eggs in small loose rafts (average of 30 eggs per raft) on raspberry leaves. Nymphs hatch and pass through five instars before becoming adults; nymphs are cream and yellow with prominent dark markings. The nymphs and adults pierce plants with needle-like mouthparts sucking sap from buds and blossoms. Adults and nymphs also feed directly on green, ripening and ripe raspberries causing discolouration and reduced firmness. Spiders and bugs are major predators, particularly of eggs and young nymphs. Eggs are also parasitised by *Trissolcus* and *Telenomus* sp. (Figure 90).
Harlequin bug (*Dindymus versicolor*)

Harlequin bug (*Dindymus versicolor*) is a native Australia plant bug. The adult bug is about 12 mm long. Mating adults can be seen in pairs joined at the abdomen and facing in opposite directions. The harlequin bug is a sap sucker that uses a needle-like mouthpart to pierce the epidermis of the host plant tissue. The severity of damage in some orchards seems to be associated with bugs having easy access to plants either by weed growth within rows, trellis posts, wires and irrigation. Due to its association with certain weed species, weed control in the orchard is key to reducing the likelihood and intensity of infestations. Weeds *Malva spp.* (marshmallow), *Rumex spp.* (docks) and *Polygonum aviculare* (wire weed) have been shown to act as a host for harlequin bugs. Maintaining a weed-free strip under the plants will reduce available shelter and protected access to the plants.

Leafhoppers (Jassids)

Jassids or leafhoppers are small green to yellow sap-sucking insects that are about 5 mm long. Jassids insert eggs into plant tissues. The nymphs are similar to the adults but have no wings. Jassids suck from the cells of the leaves, with each feeding puncture killing some of the cells. The damage shows up as small white spots and continued feeding results in a typical jassid stipple pattern on the leaves (Figure 92). Predatory bugs and spiders will attack leafhoppers; unnecessary sprays will adversely affect these and other beneficial insects.

Lepidoptera – helicoverpa and looper

The helicoverpa caterpillar can be up to 50 mm long and are initially pale green, sometimes with black dots and a pattern of thin dark lines running along the body (Figure 93). This species feeds on leaves and fruit and is capable of causing large amounts of damage.

Looper caterpillars are green and move with a distinctive looping action (Figure 94). They chew on the leaf surface and fruit, leaving large holes.
Natually occurring beneficials such as parasitoids (e.g. *Trichogramma* spp. and tachinid flies), predatory bugs, spiders and lacewings attack these caterpillars, the pupa and the eggs laid by the moths.

**Rutherglen bugs (** *Nysius vinitor** **)**

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 are silvery and shorter and the upper pair is darker silver with dark lines trailing the edges (Figure 95). Nymphs are reddish brown, pear-shaped and wingless and range in size from 1 mm to 5 mm (Figure 96). Rutherglen bugs have a wide host range and are strong fliers which migrate in swarms. They are influenced strongly by weather and are most prevalent in dry spring weather following a wet winter. Rutherglen bugs cause damage by sucking sap from fruit and leaves. Managing weeds around the crop can reduce the likelihood of bugs moving from weeds into the crop.

**Queensland Fruit fly (** *Bactrocera tryoni** **)**

Queensland fruit flies (QFF) (*Bactrocera tryoni*) are about 6–8 mm long and are reddish brown with yellow markings (Figure 97). They are most active in warm humid conditions and after rain. Adults emerge in spring and seek out maturing fruit to lay eggs under the skin. The larvae feed inside the fruit, creating internal rots and fruit-fall. The female fruit fly must feed on a source of protein before her eggs will mature. A single control method by itself is not sufficient to eradicate QFF from an area. The best results are gained from a combination of methods such as population monitoring by trapping, area saturation with male annihilation treatment (MAT) – using pheromones to attract and kill males, protein bait sprays and strict orchard hygiene practices. It is important to remove unwanted hosts such as feral and neglected fruit trees, remove all leftover fruit following harvest and destroy any fallen fruit if damaged by fruit fly.
Two-spotted mite (Tetranychus urticae)

The two-spotted spider mite (Tetranychus urticae) is most commonly found in red raspberries and increases in numbers during warm weather. The mites have eight legs, are about 0.05 cm long and vary in colour from pale green to crimson red (Figure 98). Under high infestation, leaves are marked by white stippling or bronzing after the mites have fed (Figure 99). Severe damage can reduce yield and fruit quality.

Growers should aim to establish sufficient populations of biological control agents to eliminate the need for spraying for two-spotted mites. Applying 'hard' pesticides to control other pests often leads to outbreaks of two-spotted mites because biological control agents are eliminated. It is useful to monitor populations of both two-spotted mites and their biological control agents and delay making miticide applications until it is necessary. Predatory mites such as Phytoseiulus persimilis and Neoseiulus californicus are commercially available for purchase in Australia and can be introduced into orchards. Other management techniques likely to reduce a two-spotted mite outbreak include measures to reduce dust and ensuring adequate irrigation.
Orchard management: raspberries and blackberries

This section of the guide contains information directly related to managing raspberry and blackberry pests and diseases. This guide lists the most common pests and diseases that growers should be on the lookout for over a typical growing season.

Pest and disease management

» Not all pesticides registered for a particular condition are mentioned.

» Each group of chemicals is intended to show compounds recommended for a particular situation. The list is not in order of effectiveness.

» Recommendations are intended to be consistent with registered labels or product permits. Growers need to follow the rate on the permit, as the rate for Rubus will not be on the label if not registered.

» No information on rates (quantity of product in the spray mix) is given in the guide. This information appears on the product label if registered and on the permit if permitted.

» Check the product label for specific instructions and warnings.

Use of chemical names

The information given in the following pages is intended as a guide for raspberry growers and sometimes it is necessarily general. Use of chemical names (active ingredients) in the recommendations is to simplify the entries. Such use implies that at least one product (trade name) containing that chemical is registered or permitted for that use. However, it should not be assumed that all products containing that active ingredient are registered for the same use. The pesticide user is responsible for checking the product label or permit to be used to ensure that the proposed use is legal and that all directions (rates, timing, warnings etc.) are observed.

Guide to chemical groups

The letter in brackets that appears after a chemical name (e.g. copper hydroxide (M1)) refers to its mode of action (MOA) chemical group. This is to help you to quickly identify chemical groups to manage resistance (see Avoiding resistance to pesticides on page 86).

Resistance management

A fundamental aspect of any integrated pest and disease management (IPDM) strategy is which pesticide or pesticides that are used. The primary consideration is to rotate chemicals so that the pest, disease or weed is not continually exposed to the same MOA group. To do this successfully, growers need to be able to identify chemical groups. You can do this by checking the activity group identification symbol, which all registered pesticides have on their labels, e.g. 1B, 11, 18.

Colour coding of pesticides

Trade names (in brackets) are only included where only one product is registered for that common name. Coloured dots before the chemical common name denote that chemical’s compatibility with IPM.

1 indicates that – when used with care – a chemical will have very little effect beneficials and is recommended in an IPDM program.

2 indicates that this pesticide can be used with caution in an IPDM program, but the beneficials present and the chemical’s likely effect should be assessed before application.

3 indicates that this chemical is likely to have a long-lasting, negative off-target impact (including affecting beneficial arthropods) and should only be used in an emergency where no alternative exists.
### Table 7. Raspberries and blackberries – calendar

<table>
<thead>
<tr>
<th>Reason</th>
<th>Biocontrol treatments</th>
<th>Chemical treatments</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternaria leaf spot and fruit rot</td>
<td>N/A</td>
<td>Boscalid + Pyraclostrobin (Pristine) PER13087</td>
<td>7,11</td>
<td>1</td>
<td>Apply a maximum of three foliar spray applications within an annual production cycle. Consecutive treatments should be applied 7—14 days apart. Do not apply more than two consecutive applications, before using a fungicide from another MOA group.</td>
</tr>
<tr>
<td>Anthracnose and Anthracnose (cane spot)</td>
<td>N/A</td>
<td>Azoxystrobin PER14509</td>
<td>11</td>
<td>1</td>
<td>Begin applications at the onset of the disease. Apply a maximum of three applications per season. Do not apply more than two consecutive applications with a re-treatment interval of 14 days. Where consecutive applications of azoxystrobin are used they must be followed by at least the same number of applications of fungicides from a different group before azoxystrobin is used again in the current or following season.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boscalid + Pyraclostrobin (Pristine) PER13087</td>
<td>7,11</td>
<td>1</td>
<td>Use preventatively. Start applications when conditions favour disease infection. Apply a maximum of three foliar spray applications within an annual production cycle. Consecutive treatments should be applied 7—14 days apart. Do not apply more than two consecutive applications, before using a fungicide from another MOA group for two applications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper as oxychloride</td>
<td>M1</td>
<td>1</td>
<td>Apply at bud movement.</td>
</tr>
<tr>
<td>Botrytis</td>
<td>N/A</td>
<td>Azoxystrobin PER14509</td>
<td>11</td>
<td>1</td>
<td>Begin applications at the onset of the disease. Apply a maximum of three applications per season. Do not apply more than two consecutive applications with a re-treatment interval of 14 days. Where consecutive applications of azoxystrobin are used they must be followed by at least the same number of applications of fungicides from a different group before azoxystrobin is used again in the current or following season.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boscalid + Pyraclostrobin (Pristine) PER13087</td>
<td>7,11</td>
<td>1</td>
<td>Use preventatively. Spraying should start from the white bud stage onwards. Flowers are not susceptible to infection until they are open, and symptoms of the disease are often not visible until after ripening. Apply a maximum of three foliar spray applications within an annual production cycle. Consecutive treatments should be applied 7—14 days apart. Do not apply more than two consecutive applications, before using a fungicide from another MOA group for two applications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Captain PER13958</td>
<td>M4</td>
<td>1 (raspberries) 14 (blackberries)</td>
<td>First application should occur after green tip. Spray and then repeat every 10—14 days until the season ends.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chlorothalonil PER14449</td>
<td>M5</td>
<td>Do not apply later than 28 days before harvest</td>
<td>Apply at early bloom, two weeks later and at veraison.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper as oxychloride (Raspberries only)</td>
<td>M1</td>
<td>1</td>
<td>Apply at bud movement, pre blossom and repeat at petal fall and after harvest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyanocarb PER14422</td>
<td>J</td>
<td>1</td>
<td>Apply as a protectant spray at the first signs of infection or at white bud. Do not exceed a maximum of four sprays per crop per season with no more than two applications sequentially (7—14 days apart) before using another fungicide from another chemical group. Do not apply more than four applications per season.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fenchlorid PER14424</td>
<td>J</td>
<td>1</td>
<td>Apply at first sign of infection or at white bud. Do not exceed a maximum of 4 applications per crop per season with no more than two applications sequentially before using another fungicide from a different chemical group. Allow a minimum re-treatment interval of 7—10 days between consecutive applications. Do not apply in less than 500 L/ha of spray volume.</td>
</tr>
</tbody>
</table>
### Table 7. Raspberries and blackberries – calendar (continued)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Biocontrol treatments</th>
<th>Chemical treatments</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botrytis</td>
<td>N/A</td>
<td>Fenhexamid</td>
<td>J</td>
<td>1</td>
<td>Apply at first sign of infection or at white bud. Do not exceed a maximum of 4 applications per season with no more than two applications sequentially before using another fungicide from a different chemical group. Allow a minimum re-treatment interval of 7–10 days between consecutive applications. Do not apply in less than 500 L/ha of spray volume.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PER14424</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ipodione (Raspberries only)</td>
<td>2</td>
<td>1</td>
<td>Spray at 10% blossom and full bloom. For fruit protection, apply at 2–3 weeks pre-harvest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mancozeb PER13958</td>
<td>M3</td>
<td>7</td>
<td>Apply at early bloom and repeat at 10–14 day intervals. Use a lower interval when disease threat is higher.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pyrimethanil (Scala)</td>
<td>PER13958</td>
<td>9</td>
<td>Do not apply more than 2 L of product per hectare. Applications should be made at critical times (when conditions favour disease development). Use sufficient amounts of water to achieve adequate flower coverage and adequate canopy penetration.</td>
</tr>
<tr>
<td>Cladosporium</td>
<td>N/A</td>
<td>Azoxyostrobin</td>
<td>T1</td>
<td>1</td>
<td>Begin applications at the onset of the disease. Apply a maximum of three applications per season. Do not apply more than two consecutive applications with a re-treatment interval of 14 days. Where consecutive applications of azoxystrobin are used they must be followed by at least the same number of applications of fungicides from a different group before azoxystrobin is used again in the current or following season.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PER14509</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downy mildew</td>
<td>N/A</td>
<td>Chlorothalonil</td>
<td>M5</td>
<td>Do not apply later than 28 days before harvest</td>
<td>Apply when conditions favour disease, then repeat at 7–14 day intervals. Do not apply more than three sprays per year. Use shorter intervals when disease pressure is high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PER14449</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copper as oxychloride (Raspberries only)</td>
<td>M1</td>
<td>1</td>
<td>First apply when shoots are 10 cm long. Reapply at 10–14 day intervals. Canes must not be bearing fruit.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mancozeb PER13958</td>
<td>M3</td>
<td>7</td>
<td>Apply early bloom and repeat at 10–14 day intervals. Use lower interval when threat of disease is higher.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metalaxyl-M + Mancozeb (Ridomil Gold)</td>
<td>4, M3</td>
<td>14</td>
<td>Apply a maximum of two consecutive applications when conditions favour disease development. Apply at 14-day intervals from bud burst to pre-flowering, reducing to 10-day intervals from tight cluster to early fruit formation. Apply a maximum of four foliar spray applications within an annual production cycle.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PER14238</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green stink bug</td>
<td>General predators and parasites</td>
<td>Pyrethrin PER80070</td>
<td>3A</td>
<td>Not required when used as directed</td>
<td>Detecting the pest early is important for good control. Monitor for eggs and egg hatching. Apply first spray at about 50% egg hatching. Apply a follow up spray at 100% egg hatch. Apply as a foliar application only. Minimum re-treatment interval of 1–2 days.</td>
</tr>
<tr>
<td>Green vegetable bug</td>
<td>General predators and parasites</td>
<td>Pyrethrin PER80070</td>
<td>3A</td>
<td>Not required when used as directed</td>
<td>Detecting the pest early is important for good control. Monitor for eggs and egg hatching. Apply first spray at about 50% egg hatching. Apply a follow up spray at 100% egg hatch. Apply as a foliar application only. Minimum re-treatment interval of 1–2 days.</td>
</tr>
<tr>
<td>Leafhoppers (Jassids)</td>
<td>General predators</td>
<td>Dimethoate</td>
<td>1B</td>
<td>7</td>
<td>Apply when pest first appears and repeat at 3–weekly intervals or as necessary.</td>
</tr>
</tbody>
</table>
### Table 7. Raspberries and blackberries – calendar (continued)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Biocontrol treatments</th>
<th>Chemical treatments</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lepidoptera (Helicoverpa and Looper)</strong></td>
<td>Bacillus thuringiensis <strong>AND</strong> Green lacewings (Mallada signata) <strong>AND</strong> Brown lacewings (Micromus tasmaniae) <strong>AND</strong> Trichogramma pretiosum <strong>AND</strong> Damsel bug (Nabis kirbergii)</td>
<td>Armigen Helicoverpa Biocontrol (Nuclear polyhedrosis virus of helicoverpa armigera) <strong>OR</strong> Carbaryl (Raspberries only) <strong>OR</strong> Spinetoram</td>
<td>Not required when used as directed</td>
<td>7 days</td>
<td>Use a high rate when flowers, fruit or economic parts of the crop are present; under high pest pressure conditions, or to control larvae larger than 7 mm long. Armigen as a short residual activity and retreatment may be required at 2–3 day intervals. Use a non-ionic surfactant at the manufacturer’s specified rate to improve coverage. Optimax can be used when enhanced performance of Helicoverpa NPV is required. <strong>Apply at the first sign of pests and repeat as required. Do not spray when bees are active.</strong></td>
</tr>
<tr>
<td><strong>Light brown apple moth</strong></td>
<td>Trichogramma carverae <strong>AND</strong> Bacillus thuringiensis</td>
<td>Carbaryl (Raspberries only) <strong>OR</strong> Indoxacarb PER13289 <strong>OR</strong> Spinetoram</td>
<td>1A, 1 day</td>
<td>7 days</td>
<td><strong>Spray when pests are first seen and repeat at 7–14 day intervals when pests are active. Spray all foliage including the under surfaces of leaves. Ensure spray coverage to the point of runoff. Do not spray when bees are active.</strong></td>
</tr>
<tr>
<td><strong>Phomopsis</strong></td>
<td>N/A</td>
<td>Boscalid + Pyraclostrobin (Pristine) PER13087</td>
<td>7,11</td>
<td>1 day</td>
<td>Apply maximum of three foliar sprays applications within an annual production cycle. Consecutive treatments should be applied 7–14 days apart. Do not apply more than two consecutive applications, before using a fungicide from another MOA group.</td>
</tr>
<tr>
<td><strong>Phytophthora root rot</strong></td>
<td>N/A</td>
<td>Metalaxyl (Ridomil) PER13958</td>
<td>4</td>
<td>48 days</td>
<td>Controls germinating weed seeds and soil-borne pathogens as per APVMA approved label. <strong>Apply the product directly to the soil and then water in.</strong></td>
</tr>
<tr>
<td></td>
<td>Metham (NSW only) PER82024 <strong>OR</strong> Phosphonic acid (Agri-fos, Phospot) PER13958</td>
<td></td>
<td></td>
<td></td>
<td><strong>Preplanting:</strong> Planting may take place 14–21 days after application if the soil is a light–medium texture and not excessively wet or cold. A minimum 30-day interval is necessary where soil texture is heavy, high in organic matter, wet, or soil temperature is less than 15 °C. A 60-day interval is required if application rate is greater than 1100 L/ha. Cultivate on wet, heavy soils to prevent crusting and promote drying, 5–7 days after application. Sow an indicator crop such as lettuce or radish approximately seven days before main crop to test that no toxic Metham remains in the soil. Check for root damage, which will indicate whether or not the soil is still toxic. <strong>Apply to foliage by boom spray, airblast spray or backpack sprayer. Ensure thorough coverage of crop. Apply a maximum of three applications.</strong></td>
</tr>
<tr>
<td>Reason</td>
<td>Biocontrol treatments</td>
<td>Chemical treatments</td>
<td>Fungicide group</td>
<td>WHP days</td>
<td>Remarks</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>----------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>Typhlodromips montdorensis</td>
<td>Bifenthrin</td>
<td>3A</td>
<td>1 day</td>
<td>Timing of application will be at flowering when the numbers of thrips are sufficient to require control. Growers should monitor thrips numbers and spray when economic damaging thresholds are reached. Apply a maximum of 4 foliar applications with minimum re-treatment interval of 7 days using air blast sprayers.</td>
</tr>
<tr>
<td>Powdery mildew</td>
<td>N/A</td>
<td>Boscalid + Pyraclostrobin (Pristine)</td>
<td>PER13087 OR</td>
<td>7,11</td>
<td>Use preventatively. Start applications when conditions favour disease infection. Apply maximum of three foliar sprays applications within an annual production cycle. Apply consecutive treatments 7–14 days apart. Do not apply more than two consecutive applications, before using a fungicide from another MOA group for two applications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fenamiphos</td>
<td>3</td>
<td>14</td>
<td>Apply when disease first appears and repeat at 14–21 day intervals. Use a higher rate and shorter intervals when disease pressure is high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mancozeb</td>
<td>M3</td>
<td>7</td>
<td>Apply early bloom and repeat at 10–14 day intervals. Use a lower interval when disease threat is higher.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Triadimenol (Bayfian)</td>
<td>PER13958 OR</td>
<td>3</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 disease.</td>
</tr>
<tr>
<td>Monolepta Beetle</td>
<td>N/A</td>
<td>Bifenthrin</td>
<td>3A</td>
<td>1</td>
<td>Spray when adults are observed. Apply a maximum of four foliar applications with a minimum re-treatment interval of seven days using air blast sprayers.</td>
</tr>
<tr>
<td>Queensland Fruit Fly</td>
<td>General predators and parasites</td>
<td>Carbaryl</td>
<td>1A</td>
<td>7</td>
<td>Apply at the first sign of pests and repeat as required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dimethoate</td>
<td>1B</td>
<td>7</td>
<td>Apply when pests first appear and repeat at 3-weekly intervals or as necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abamectin</td>
<td>6</td>
<td>7</td>
<td>Apply on a weekly basis starting from a month prior to harvest (i.e. green berry stage) through to the end of the berry harvest. Apply approximately 7 days between consecutive spray applications. Direct spray toward the base of bushes where fruit bearing is sparse. Apply no more than four sequential spray applications of abamectin before switching to another registered fruit fly insecticide from another chemical group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spinetoram</td>
<td>S</td>
<td>1</td>
<td>Do not apply more than four applications per season, with a minimum of 7–14 days between consecutive sprays. Spinetoram must be used in conjunction with other control strategies to be effective in reducing fruit fly damage.</td>
</tr>
</tbody>
</table>
### Table 7. Raspberries and blackberries – calendar (continued)

<table>
<thead>
<tr>
<th>Reason</th>
<th>Biocontrol treatments</th>
<th>Chemical treatments</th>
<th>Fungicide group</th>
<th>WHP days</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-spotted mite</td>
<td><strong>Phytoseiulus</strong></td>
<td>Abamectin</td>
<td>6</td>
<td>7</td>
<td>Apply using ground application equipment to the point of runoff. Thorough coverage and penetration into bushes is essential. Do not use more than two applications per crop, with a minimum 28-day retreatment interval between consecutive applications.</td>
</tr>
<tr>
<td></td>
<td>Perimilis AND</td>
<td>Bifenazate</td>
<td>Unallocated</td>
<td>1</td>
<td>Apply to the point of run-off using airblast sprayer as soon as mites appear. Do not apply more than two applications per crop per season, with a minimum 21-day interval between consecutive applications. Do not use if rainfall is expected before spray can dry, as reduced efficacy may result. Do not apply sequential applications.</td>
</tr>
<tr>
<td></td>
<td><strong>Neoseiulus</strong></td>
<td>Dimethoate</td>
<td>1B</td>
<td>7</td>
<td>Apply when the pest first appears and repeat at 3-weekly intervals or as necessary. Some spider mite strains are resistant to organophosphorus compounds.</td>
</tr>
<tr>
<td></td>
<td>Californicus AND</td>
<td>Emulsifiable botanical oil</td>
<td>Not required when used as directed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Typhlodromus</strong></td>
<td>Petroleum oil</td>
<td>L</td>
<td>1</td>
<td>Using an airblast type sprayer, spray every 5 – 7 days or as required.</td>
</tr>
<tr>
<td></td>
<td>occidentals AND</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Green lacewing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>(Malada signata)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td>N/A</td>
<td>Boscalid + Pyraclostrobin (Pristine)</td>
<td>7,11</td>
<td>1</td>
<td>Apply a maximum of three foliar spray applications within an annual production cycle. Thorough coverage of foliage is essential. Do not apply more than two consecutive applications before using a fungicide from another MOA group.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chlorothalonil</td>
<td>M5</td>
<td></td>
<td>Do not apply later than 28 days before harvest. Apply when conditions favour disease, then repeat at 7 – 14 day intervals. Do not apply more than three sprays per year. Use shorter intervals when disease pressure is high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper as Cu oxychloride</td>
<td>1</td>
<td></td>
<td>Apply at bud movement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper as cupric hydroxide</td>
<td>Not required when used as directed</td>
<td></td>
<td>Apply by air blast sprayer to canes approximately one week after planting. Apply one application only. Canes must not be bearing fruit at the time of application.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mancozeb</td>
<td>M3</td>
<td>7</td>
<td>Apply at early bloom and repeat at 10 – 14 day intervals. Use a lower interval when disease threat is higher.</td>
</tr>
</tbody>
</table>

### Table 8. Pesticides: chemicals registered/permitted for managing raspberries and blackberries

<table>
<thead>
<tr>
<th>To manage...</th>
<th>Pesticide common name (trade name)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracnose</td>
<td>🍋 Azoxystrobin</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>🍋 Boscalid + Pyraclostrobin (Pristine)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>🍋 Copper</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td>Botrytis</td>
<td>🍋 Azoxystrobin</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>🍋 Boscalid + Pyraclostrobin (Pristine)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>🍋 Captan</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>🍋 Chlorothalonil</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td>To manage...</td>
<td>Pesticide common name (trade name)</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Botrytis</td>
<td>Ciproconazole + Fludioxonil (Switch)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Fenhexamid</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Iprodione</td>
<td>Contact fungicide with protective and curative action</td>
</tr>
<tr>
<td></td>
<td>Mancozeb</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Pyrimethanil (Scala)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td>Downy mildew</td>
<td>Chlorothalonil</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Mancozeb</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Metalaxyl-M + Mancozeb (Ridomil Gold)</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td>Green stink bug</td>
<td>Pyrethrin</td>
<td>Contact insecticide — non selective</td>
</tr>
<tr>
<td>Green vegetable bug</td>
<td>Pyrethrin</td>
<td>Contact insecticide — non selective</td>
</tr>
<tr>
<td>Leafhoppers (Jassids)</td>
<td>Dimethoate</td>
<td>Contact insecticide with larvicidal and ovicidal activity, 8–12 weeks residue</td>
</tr>
<tr>
<td>Lepidoptera (Helicoverpa and looper)</td>
<td>Armigen Helicoverpa</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Carbaryl</td>
<td>Contact insecticide with stomach action, 4 weeks residue</td>
</tr>
<tr>
<td></td>
<td>Spinetoram</td>
<td>Insecticide with contact action</td>
</tr>
<tr>
<td>Light brown apple moth</td>
<td>Carbaryl</td>
<td>Contact insecticide with stomach action, 4 weeks residue</td>
</tr>
<tr>
<td></td>
<td>Indoxacarb</td>
<td>Narrow insecticide with contact and stomach action</td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td>Metalaxyl (Ridomil)</td>
<td>Protectant fungicide with slow release activity</td>
</tr>
<tr>
<td></td>
<td>Phosphonic acid (Agri-fos, Phospot)</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td>Plague thrips</td>
<td>Bifenthrin</td>
<td>Insecticide, acaricide with contact and stomach action, 8–12 weeks residue</td>
</tr>
<tr>
<td>Powdery mildew</td>
<td>Boscalid + Pyraclostrobin (Pristine)</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Fenarimol</td>
<td>Fungicide with protectant and some curative action</td>
</tr>
<tr>
<td></td>
<td>Mancozeb</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td>Monolepta beetle</td>
<td>Bifenthrin</td>
<td>Insecticide, acaricide with contact and stomach action, 8–12 weeks residue.</td>
</tr>
<tr>
<td></td>
<td>Pyrethrin</td>
<td>Contact insecticide, non-selective</td>
</tr>
<tr>
<td>Rutherglen bug</td>
<td>Carbaryl</td>
<td>Contact insecticide with stomach action, 4 weeks residue</td>
</tr>
<tr>
<td></td>
<td>Dimethoate</td>
<td>Contact insecticide with larvicidal and ovicidal activity, 8–12 weeks residue</td>
</tr>
<tr>
<td>Queensland fruit fly</td>
<td>Abamectin</td>
<td>Acaricide with stomach action and translaminar movement, 1–2 weeks residue</td>
</tr>
<tr>
<td></td>
<td>Maldison</td>
<td>Contact insecticide with stomach and respiratory action</td>
</tr>
<tr>
<td></td>
<td>Spinetoram</td>
<td>Insecticide with contact action</td>
</tr>
<tr>
<td>Two-spotted mite</td>
<td>Abamectin</td>
<td>Acaricide with stomach action and translaminar movement, 1–2 weeks residue.</td>
</tr>
<tr>
<td></td>
<td>Bifenazate</td>
<td>Acaricide with contact and residual activity against motile stages</td>
</tr>
<tr>
<td></td>
<td>Dimethoate</td>
<td>Contact insecticide with larvicidal and ovicidal activity, 8–12 weeks residue</td>
</tr>
<tr>
<td></td>
<td>Emulsifiable botanical oil</td>
<td>Insecticide with respiratory action</td>
</tr>
<tr>
<td></td>
<td>Petroleum oil</td>
<td>Insecticide and acaricide with ovicidal activity</td>
</tr>
<tr>
<td>Yellow rust</td>
<td>Chlorothalonil</td>
<td>Protectant fungicide</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>Protectant fungicide/bactericide</td>
</tr>
<tr>
<td></td>
<td>Copper as cupric hydroxide</td>
<td>Protectant fungicide/bactericide</td>
</tr>
<tr>
<td></td>
<td>Mancozeb</td>
<td>Protectant fungicide</td>
</tr>
</tbody>
</table>

1 Source: APVMA Pubcris.  
Trade names (in brackets) are only included where only one product is registered for that common name. Coloured dots before the chemical common name denote that chemical’s compatibility with IPM.  
1 indicates that — when used with care — a chemical will have very little impact on beneficials and is recommended in an IPM program.  
2 indicates that this pesticide can be used with caution in an IPM program, but the beneficials present and the chemicals likely impact should be assessed prior to application.  
3 indicates that this chemical is likely to have a long-lasting, negative off-target impact (including an impact on beneficial arthropods) and it should only be used in an emergency where no alternative exists.  
Weed management

Why manage weeds?
Rapid canopy establishment and early cropping are key to profitability in any orchard block, particularly modern capital intensive systems. Weeds compete with trees for moisture and nutrients and can create a microclimate that is favourable to pests and disease.
Research shows that competition from weeds in young, developing orchards can slow canopy establishment and delay productivity. In high density blueberry orchards, the risks from weed competition are heightened in young plantings due to the openings in weedmat, which places plant roots in direct competition with weeds. A poor weed management strategy will also negatively affect yields in established orchards.
Having an effective weed management strategy in place will help growers to achieve their goals for orchard establishment, early yields and hygiene.

Hygiene comes first
Good orchard hygiene should be the first step in any weed management strategy. New weed species and weed movement on and throughout your property are largely determined by the degree of weed hygiene employed.
Be aware as new weeds appear on your property. Have them identified if necessary, and put a plan in place to eradicate them or reduce their spread. Machinery moving from non-crop areas to the orchard and between blocks is the most likely way to spread new weeds, plus placing organic mulches around plant holes. Regularly cleaning orchard equipment is a useful practice to help prevent new weeds from spreading.

Management strategies and control options
The most appropriate weed management strategy will vary from site to site and will depend on a number of factors including orchard size, plant age, weed spectrum and density, soil type, available moisture and choice of under plant or row management (i.e. bare earth, mulched or sod culture). Over time, strategies will need to change in response to changes in the weed spectrum and growing conditions.
Methods of weed management can be grouped as either physical or chemical and a strategy can incorporate elements of both.

Physical weed control methods
Physical methods of weed control include cultivation, thermal weeding, grazing and mulching.

Cultivation
Cultivation was once a common commercial practice in orchards and does reduce competition from weeds, but at some cost. Disturbing top soil is now known to negatively affect soil structure, organic matter levels and can result in some root damage to trees, especially in blocks on dwarf stocks. Cultivation also increases the risk of erosion. Spot cultivation using a hoe is very 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 occupational health and safety issues and fire hazards associated with these methods. Do not use thermal weeding near trees less than three years old as severe crop damage can occur.

Grazing animals
Grazing with animals such as sheep, geese and fowls can be used to suppress weed growth and reduce seed load in the orchard. Geese are heavy feeders of weeds such as grasses, and they also help to clean-up windfall fruit. Sheep can cause damage to trees if other feed is scarce.
If orchard grazing animals are intended for sale, be aware of chemical residue issues. Consult chemical labels for information on stock withholding periods.

Mulching
Mulching, if done correctly, represents 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 as a weed control, mulch must be applied at sufficient thickness to act as a physical barrier to sunlight and weed growth and this will depend on the type of mulch being applied. In blueberry orchards with bushes planted on mounds in rows, it is essential
to form broad mounds if organic mulches are to be used, so that the mulch material does not slide off the mound. To stop weeds, as the mulch decomposes, it will also need to be renewed 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 tree row, which can help to suppress weeds and build up organic matter, but experience has shown that 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 climates. It is effective at reducing weeds on mounds, but it can lead to disease problems and soil health issues inside mounds.

Many growers use both 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 additional rainfall.

**Chemical weed control**

Chemical herbicides have been the mainstay of weed management in orchards since the mid 1940s. Using herbicides remains the most cost effective and reliable approach to managing weeds in commercial orchards.

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

Orchard herbicides can be grouped into three broad categories:

1. pre-emergent residual herbicides
2. post-emergent non-selective
3. post-emergent selective (grass herbicides).

Generally speaking, 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.

**Post-emergent non-selective herbicides** (knockdowns) perform best when applied to young, actively growing broadleaf weeds and some grasses. Due to their non-selective nature, many herbicides in this group can be very harmful to fruit trees. Young trees are particularly prone to injury if not protected from knockdown herbicides. Consult product labels for specific recommendations.

**Post-emergent selective grass herbicides** are useful where the predominant weed species present is a grass.

**Pre-emergent herbicides** are designed to perform best if applied to bare soil that is totally weed- and trash-free. Any material that prevents the pre-emergent herbicide from contacting and incorporating in the soil surface will reduce the level of control over germinating weeds. Most pre-emergent herbicides will give good control of a wide range of annual broad leaf weeds and grasses if applied correctly.

Tables 9 and 10 on page 65 provide a summary of information on the range of active ingredients available for use in blueberry, raspberry and blackberry orchards. **IMPORTANT:** Please read the product label thoroughly before applying any herbicide in your orchard. Failure to do so could result in a poor product performance or even damage to your trees.

**Should I be concerned about resistance?**

The short answer is Yes! Glyphosate resistant ryegrass is present in orchards and vineyards across Australia and this is due to 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 the 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 likely susceptibility to resistance. Refer to the tables 9 and 10 on page 65 or the product label to determine the MOA group.

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

- Know your herbicide groups and don’t 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 an A group herbicide when an L or M group herbicide will do the job.
- Look for surviving weeds after spraying and prevent these from setting seed.
- Use as many weed control techniques as practicable and do not rely solely on herbicides.

**Herbicide sprayer setup**

A properly configured and well calibrated sprayer is essential to ensure your herbicides are applied in accordance with label recommendations and that you achieve the weed control result that you are hoping for. 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 gauge is in accurate working order.
- Use the correct (specified) pressure range for the nozzles being used.
- Flat fan nozzles have traditionally been the popular choice for herbicide spraying, BUT these are no longer appropriate when it comes to reducing spray drift. For more information refer to section on Managing spray drift on page 76.
Always use a low-drift type nozzle wherever possible, such as an air induction or Al nozzle.

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; too high will increase the risk of off-target damage.

If an individual nozzle’s output (L (litres) per minute) varies by more than 5% from the manufacturers’ specifications, replace the nozzles in question.

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 calibration of herbicide spray equipment is:

Select the tractor engine rpm and gear to give a satisfactory ground speed in the orchard and the correct pump pressure.

Fill the spray tank with water and note the exact level reached.

Measure a 100 m strip and spray over it with water.

Measure the width of the sprayed strip.

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:

Assume:

- Tank capacity \( T \) = 500 L
- Length of sprayed area \( L \) = 100 m
- Width of sprayed area \( W \) = 1.5 m
- Volume of water used in test spray used in test spray \( V \) = 10 L
- Rate of application of commercial product \( R \) = 3.75 kg/ha

Then:

**Area covered by full tank is**

\[
L \times W \times T \div V
\]

In our example, the area covered is

100 m × 1.5 m × 500 L ÷ 10 L

= 7500 square metres or 0.75 ha

(there are 10,000 square metres per hectare)

**Herbicide required in a full tank**

= area covered by a full tank × rate of application \( R \)

In our example the amount of herbicide required

= 0.75 ha × 3.75 kg/ha = 2.8 kg
## Table 9. Herbicides and their uses for blueberries:

Non-selective post-emergent 'knockdown' herbicides – read the label before use.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Trade names</th>
<th>Herbicide group</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glufosinate-Ammonium (Permit number – PER81429 Expires 30 June 2019)</td>
<td>Basta N</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 uncaloused and damaged blueberry plants.</td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Roundup® M</td>
<td>Not required when used as directed</td>
<td>Control of 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 trees less than three years old unless they are properly protected from spray drift.</td>
<td></td>
</tr>
<tr>
<td>Paraquat</td>
<td>Inforno L</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>
<td></td>
</tr>
</tbody>
</table>

Residual herbicides – long-term control of a range of weeds depending on rate applied, rainfall and irrigation, and soil type. Read the label before use. Best results are achieved when applied to bare soil. Established perennials such as paspalum will not be controlled without use of a post-emergent herbicide.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Trade names</th>
<th>Herbicide group</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichlobenil (Permit number – PER12219 Expires 31 March 2019)</td>
<td>Carson G, Sienaron K</td>
<td>Not required when used as directed</td>
<td>Annual grasses and broadleaf weeds.</td>
<td>Do not apply more than 2 applications per year. Apply using granular chemical applicator. Apply first application prior to budburst and second application following final harvest.</td>
<td></td>
</tr>
<tr>
<td>Oryzalin</td>
<td>Stonewall® O</td>
<td>Not required when used as directed</td>
<td>For pre-emergent control of certain annual grasses and broadleaf weeds.</td>
<td>Activated by moisture. For use on non-bearing trees only.</td>
<td></td>
</tr>
</tbody>
</table>

Post-emergent selective grass herbicides – only control grasses, not broadleaf weeds, sedges and rushes. Read the label before use.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Trade names</th>
<th>Herbicide group</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluazifop-P (Permit number – PER14741 Expires 30 June 2019)</td>
<td>Fusilade Forte A</td>
<td>4 weeks</td>
<td>Barnyard grass, crowsfoot grass, sinic grass, Urochloa grass, carpet grass, couch grass, Johnson grass, kikuyu, paspalum,</td>
<td>Use higher water volumes if weeds are dense.</td>
<td></td>
</tr>
<tr>
<td>Haloxyfop</td>
<td>Haloxefop 900 EC® A</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 tree to avoid contact with fruit and foliage.</td>
<td></td>
</tr>
</tbody>
</table>

## Table 10. Herbicides and their uses for raspberries and blackberries

Non-selective post emergent 'knockdown' herbicides – read the label before use.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Trade names</th>
<th>Herbicide group</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glufosinate-Ammonium</td>
<td>Basta N</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>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Roundup® M</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 trees less than three years old unless they are properly protected from spray drift.</td>
<td></td>
</tr>
</tbody>
</table>

Residual herbicides – long-term control of a range of weeds depending on rate applied, rainfall and irrigation, and soil type. Read the label before use.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Trade names</th>
<th>Herbicide group</th>
<th>Withholding period (harvest)</th>
<th>Weeds controlled</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichlobenil (Tas only)</td>
<td>Carson G*, Sienaron* O</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>
<td></td>
</tr>
<tr>
<td>Oryzalin</td>
<td>Ospray Oryzalin 500 D</td>
<td>Not required when used as directed</td>
<td>Active against a wide range of annual broadleaf weeds and grasses</td>
<td>Activated by moisture, for use on non-bearing trees only.</td>
<td></td>
</tr>
<tr>
<td>Simazine</td>
<td>Gesatop® C</td>
<td>Not required when used as directed</td>
<td>Active against a range of broadleaf weeds</td>
<td>Do not apply to foliage or when fruit is present. Use on established plants only.</td>
<td></td>
</tr>
</tbody>
</table>
Growers are moving away from the ‘sledgehammer’ approach of using broad-spectrum pesticides due to environmental and occupational health problems. Over the last 5–10 years, growers have opted for a more IPDM (integrated pest and disease management) approach. Biological control plays an important role in IPDM success. Biological control agents are natural enemies of orchard pests. They include insect predators and parasites, predatory mites and bacterial pesticides.

It is important to use biological control agents in the right way. Growers often become disillusioned when biological control agents fail to control a pest outbreak. Biological control agents are very good at maintaining pest populations at low levels that don’t cause serious damage to your crop. They are rarely useful in an emergency. Orchardists should do all they can to encourage populations of beneficial insects for biological control.

**Beneficial insects and mites**

When predatory insects and mites are allowed to increase in numbers, they can perform very effective roles in balancing the ecology in fruit orchards. As growers introduce softer chemicals into their orchards, there will be greater opportunity for beneficial insects and mites to survive.

When a pest problem arises, always consider all the control options available. If it is necessary to apply a pesticide, consider the range of effective options and choose the one which will have the least impact on biological control agents living in your orchard.

Longer term, look at which management strategies will help you boost the numbers of beneficials and rebalance the ecology in your orchard.

**Bacterial insecticides**

*Bacillus thuringiensis* (Bt) is a bacterium that is the active component of Dipel® and similar products. The bacterium is one that affects the caterpillar stage of only certain insects.

Bt is recommended for controlling painted apple moth and light brown apple moth (LBAM) and other leafrollers or caterpillars in berry fruits. If applied before infestation becomes established, it will provide control for LBAM and lepidoptera that does not disrupt other beneficials.
**Protecting biological control agents**

2. Monitor your orchard pests, beneficial insects and predatory mites to effectively time sprays.
3. Use chemicals less toxic to beneficials. Consult chemical label or *The good bug website* (http://www.goodbugs.org.au/index.html) for chemical toxicity.

4. Modify the orchard environment to encourage beneficials. Many predatory species rely on pollen from grasses, native flowers and herbs to tide them over while waiting for prey.

For further resources: visit [www.goodbugs.org.au](http://www.goodbugs.org.au) and where suppliers of beneficial insects and mites can be found ([www.goodbugs.org.au/suppliers.html#BiologicalService](http://www.goodbugs.org.au/suppliers.html#BiologicalService)).

### Table 11. Pesticides toxic to predatory mites, ladybirds and lacewings

<table>
<thead>
<tr>
<th>Pesticides</th>
<th><em>Phytoseiulus persimilis</em></th>
<th><em>Galendromus occidentalis</em></th>
<th><em>Typhlodromus pyri</em></th>
<th>Ladybirds</th>
<th>Lacewings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecticides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bifenthrin</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>X</td>
<td>X</td>
<td>0</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>X</td>
<td>0</td>
<td>X</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>Indoxacarb</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Maldison</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>Methomyl</td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Methoxyfenozide</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Primicarb</td>
<td>X</td>
<td>0</td>
<td>–</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinosad</td>
<td>X</td>
<td>0</td>
<td>X</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Trichlorfon</td>
<td>XX</td>
<td>0</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Miticides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abamectin</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>XX</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boscalid + Pyroliostrobin</td>
<td>(Pristine)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Captan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Cyprodinil + Fludioxonil</td>
<td>(Switch)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Fenarimol</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Iprodione</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mancozeb</td>
<td>X</td>
<td>0</td>
<td>XX</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Propiconazole</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Triadimenol</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Toxicity rating: XX — very harmful; X — harmful; 0 — nil or minor effect; – no data
Some books and several leaflets, Agfacts and Primefacts are mentioned in the guide. These are available from various sources, some of which are outlined below.

The following publications are available from NSW Department of Primary Industries through Tocal Agricultural College bookshop.

p: 1800 025 520
e: tocal.college@dpi.nsw.gov.au
w: www.tocal.nsw.edu.au/publication

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.

» **Interactivity.** You can use your reading app to search within the book for specific topics. Most books have linked cross-references and glossary to make them easier to navigate. Some books even have videos.

» **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/Agfacts** referred to throughout the guide usually contain illustrations of the pest or disease the Primefact/Agfact describes. These are available free from NSW Department of Primary Industries website (http://www.dpi.nsw.gov.au/content/agriculture/horticulture) and click into your product for a list.

**Spray Sense** is a publication providing 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 (http://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 & 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 growers of raspberries. The book covers topics such as propagation, soil and water management, pest and disease management and production.
Internet sites for berry growers

These Internet sites contain information that fruit growers might find useful.

**Agricultural industry organisations**
- Australian Blueberry Growers’ Association  
- Horticulture Industry Network  
- Horticulture Innovation Australia Limited  
- 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**
- NSW Department of Primary Industries  
- NSW Local Land Services  
- Office of Environment & Heritage, NSW  
- Office of Water, NSW  
- WorkCover Authority of NSW  
- Department of Environment and Primary Industries, Victoria  
- Department of Agriculture and Food, Western Australia  
- Department of Primary Industries and Regions SA, South Australia  
- Queensland Department of Agriculture and Fisheries, Queensland  
  [www.daf.qld.gov.au](http://www.daf.qld.gov.au)
- Department of Primary Industries, Parks, Water and Environment, Tasmania  

**Rural assistance**
- NSW Rural Assistance Authority  
- Health NSW  
- Centrelink  
- Rural Skills Australia  

**Federal government**
- ABC Rural Department  
  [www.abc.net.au/rural](http://www.abc.net.au/rural)
- Department of Agriculture and Water Resources  
- Land and Water Australia  
- Australian Pesticides and Veterinary Medicines Authority  
- Australian Trade Commission  
- Plant Health Australia  

**Climate**
- Commonwealth Bureau of Meteorology  
- The Long Paddock  

**Environment**
- Office of Environment & Heritage, NSW  
- Environment Protection Authority Victoria  
  [www.epa.vic.gov.au](http://www.epa.vic.gov.au)
- Department of Environment, Land, Water and Planning, Victoria  
- Department of the Environment and Energy  
- NSW Environment Protection Authority  
Alternative systems (organics)
Organic Federation of Australia
www.ofa.org.au
Australian Organic
www.austorganic.com

Economic information
Department of Agriculture and Water Resources
www.agriculture.gov.au
Australian Bureau of Statistics
www.abs.gov.au

Market price information
Postharvest Fresh
www.postharvest.com.au
Sydney Produce Surveyors Pty Ltd
www.sydprod.com.au

Technical production information
Agencies & universities
CSIRO
www.csiro.au
South Australia Research and Development Institute
www.sardi.sa.gov.au
New Zealand Ministry for Primary Industries
www.mpi.govt.nz
United Kingdom Department for Environment, Food and Rural Affairs
www.gov.uk/defra
United States Department of Agriculture (USDA)
www.usda.gov
Fruit & Nut Research & Information, University of California
fruitsandnuts.ucdavis.edu
University of Florida IFAS extension
edis.ifas.ufl.edu
Michigan State University Extension Services
msue.anr.msu.edu
North Carolina State University Extension Services
blueberries.ces.ncsu.edu
rubus.ces.ncsu.edu
Fall Creek Nursery
www.fallcreeknursery.com

Integrated pest management
Australasian Biological Control Association Inc.
www.goodbugs.org.au

Quality assurance
Freshcare Australia
www.freshcare.com.au

Post-harvest
Postharvest Fresh
www.postharvest.com.au

Blueberry nurseries
Mountain Blue Farms Nursery
Bruxner Hwy Wollongbar NSW 2477
p: (02) 6624 8258
www.mountainblue.com.au
Moondarra Wholesale Blueberry Nursery
120 Brown Road Moondarra VICTORIA 3825
p: (03) 5165 3238
www.moonblue.com.au
Glovers Tubes Nursery Propagation
1 Rickards Road Sandy Beach NSW 2456
p: (02) 6656 2388
Otway Blueberries
155 Carlisle Road Gellibrand VICTORIA 3239
p: (03) 5235 8385
Emily Hill Farm
Beaconsfield Road Emerald VICTORIA 3782
p: (03) 5944 3971

Raspberry and blackberry nurseries
Berry Plant Micropropagation
17 Frond Drive, The Patch, VIC 3792
p: 0429 384 592
www.berryplants.com.au
CleanGrow
P.O Box 199 Tooradin, VIC 3980
p: (03) 5998 3306
www.cleangrow.com.au

Berry marketing and agents
Driscoll’s Australia Pty Ltd
180 Landershute Road Landers Shoot
QUEENSLAND 4555
p: (07) 5478 8871
www.driscolls.com
Perfection Fresh Australia Pty Ltd
Level 1, 7 Underwood Rd Homebush NSW 2140
p: (02) 9763 1877
www.perfection.com.au
Y.V. Fresh Australia Pty Ltd
21 Parker Rd Silvan VICTORIA 3795
p: (03) 9737 9534
www.yvfresh.com.au
Fresh Produce Group
Shed X Sydney Markets NSW 2129
p: (02) 9704 8300
www.freshproducegroup.com
Managing your legal responsibilities in applying pesticides

Pesticides Act

The Pesticides Act 1999 is the primary legislative instrument controlling the use of pesticides in NSW and is administered by the Environment Protection Authority (EPA). 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 each use of the pesticide.

All pesticide users should take reasonable care to protect their own health and the health of others when using a pesticide. They should also make every reasonable attempt to prevent damage occurring from the use of a pesticide, such as off-target drift onto sensitive areas or harm to endangered and protected species.

A Regulation was gazetted in 2009 renewing the requirement for all commercial pesticide users, i.e. all farmers and spray contractors, to keep records of their pesticide application.

While no set form has to be used, records must include the following:

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

A form that captures all the information required by the Regulation, together with notes on how to fill it in, is included in this guide. The form and notes can also be downloaded from the department’s website. A self-carboning record book is also available from DPI. Call 1800 138 351 to order your copy of the SMARTtrain spray record book ($10.00). A number of other websites, including Spraywise, have record forms or you can download an app from Farming with apps (www.farmingwithapps.com/). More information on your 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.

Records must be made within 24 hours of application, be made in legible English, and kept for three years. The 2009 Regulation requires all commercial pesticide users to be trained in pesticide application.

Trained aerial applicators, pest control operators and fumigators is recognised as satisfying the requirements of the Regulation. Apart from these groups, all 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/on:

- public authorities, e.g. State Rail
- golf courses, sporting fields and 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 are recommended to undertake 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.
**Hazardous chemicals legislation**

Many registered pesticides are classified as hazardous chemicals and most of those that are not, pose some risk to the health of those who use them or are exposed to them.

The *Work Health and Safety Act 2011*, and the Hazardous Chemical section of the Work Health and Safety Regulation 2011, detail legal requirements of suppliers, workers and persons conducting businesses or undertakings in the workplace for hazardous chemicals management. The Act and accompanying 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 or register of all hazardous chemicals and an SDS (Safety Data Sheet) for each hazardous chemical)

» consulting with workers

» training workers

» minimising the risks arising from hazardous chemicals exposure

» health surveillance (if warranted by the risk assessment in respect of organophosphates).

Both storage and use are covered by the OHS legislation. 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. Consult your local WorkCover office for advice.

WorkCover 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 mentioned here.

**Pesticides and worker safety**

Pesticides can have both immediate (acute) effects and long term (chronic) effects on the health of people who are exposed to them.

**Acute toxicity**

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

**Poison Schedules**

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

The Poison Schedule will largely determine the Safety Directions and First Aid Instructions that appear on the label. The Safety Directions specify what personal protective equipment should be worn, and what safety precautions should be taken, e.g. ‘do not inhale spray mist’. The First Aid Instructions specify what action should be taken in the event of a poisoning. Safety Directions and First Aid Instructions can be different 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 Occupational Health and Safety Act requires resellers to provide end users with an SDS.

If you suspect a poisoning, contact the Poisons Information Centre, emergency phone (24 hr) 131 126.

**Anticholinesterase compounds**

In general, insecticides are more acutely toxic than other groups of pesticides such as herbicides or fungicides. This is because most insecticides act on the central nervous system. Of the insecticides, the most acutely toxic are the organophosphates (OPs), which depress cholinesterase enzyme activity in the central nervous system. 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 central nervous system, 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 personal protective equipment (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 workers 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) in agriculture* published by the NSW WorkCover Authority.

**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 or organic solvents, which are corrosive to the skin and eyes, and their vapours can affect the brain if inhaled. An example of such a distillate is xylene, which is highly toxic. As with the active ingredient, the exposure risk is highest when handling the concentrate. This is why pesticide labels often carry warnings to avoid inhaling the vapours, and to avoid splashes to the skin and eyes.
Routes of exposure
With all pesticides (except fumigants) the most hazardous route of exposure 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 liable to be breathed 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 or swallowing is a risk to applicators who don’t wash their hands before eating and drinking or who smoke during application. Unsecured storages represent a 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’.
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 personal protective equipment specified for re-entry on the label. The reason for setting a re-entry interval is that 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. These include newer products or older products that have been subject to a technical review by the Australian Pesticides & Veterinary Medicines Authority (formerly the NRA). 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 the longer. Crops should never be re-entered when wet from dew or light rain, irrespective of the time elapsed, unless appropriate personal protective equipment is worn.
Chronic toxicity
The effects of long-term exposure to small doses of chemical is referred to as chronic toxicity. Some of these chronic toxicity effects include:
» neurotoxic effects – on the brain and central nervous system
» reproductive
» carcinogenic – causing cancer
» endocrine disruption.
Neurotoxic effects
Organophosphate pesticides are suspected of having long-term, subtle effects on the central nervous system. The effects detected to date are slight and have only been detected in a tiny proportion of those exposed. What is clear, is 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) on the basis of 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 can be sought from a medical practitioner accredited by WorkCover 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 multiplicity of factors, it is extremely difficult to determine whether or not a particular cancer was the result of pesticide exposure or other factors. Apart from the 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 WHO (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. It is unclear whether long-term, low level exposure to endocrine-disrupting chemicals will affect human reproduction. One reason why it is difficult to establish the specific effects caused by pesticides is that we are surrounded by naturally occurring sex hormones, particularly in plants. Our exposure to naturally occurring plant hormones is far greater than to synthetic ones such as pesticides – by a factor of
40 million. Nevertheless, the US Environment Protection Authority has undertaken to develop a set of tests that will help to screen pesticides for their endocrine-disrupting potential. These tests will also be adopted by other risk assessment agencies around the world, including Australia.

The best way to manage any long-term risks of chronic pesticide effects 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 like ‘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 mixing/loading and decontaminating facilities away from surface waters and providing such facilities with bunding and sumps to prevent movement of either concentrate or rinsate into surface waters
» installing valves that prevent back-flow 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 tail water from irrigation
» spraying in an upstream direction, when it is necessary to spray near surface waters, to 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®
» avoiding disposal of used containers in surface waters and on flood plains and 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 are identified as such with the following special 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:
» applying pesticides toxic to bees early in the morning or in the evening when bees are not foraging
» notifying the apiarist when beehives are in the vicinity of crops to be sprayed to allow the hives to be removed before spraying
» where possible, using EC and granular formulations in preference to wettable powders, which are particularly hazardous to bees. (Micro-encapsulated 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 the pollen)
» using ground rigs in preference to 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
The organophosphate and carbamate insecticides can be particularly toxic to birds, especially in granular formulations. Bird kills from diazinon and carbofuran, none of which are recommended in this guide, have been well documented in Australia or 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
» immediate spillage clean up, 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 birds might see the baits
» 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 carcases where these occur in open situations
» immediately cleaning up 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.

The best way to manage any long-term adverse environmental risks is to follow the protection statements on labels, minimise spray drift, and to dispose of chemical containers and waste in accordance with label directions and codes of practice.

Managing residues resulting from pesticide application

Withholding periods (WHPs)

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 may have WHPs for both harvest and grazing.

WHPs are specific to use patterns, i.e. to chemical, crop and pest. WHPs are also product specific.

Harvest WHPs can vary with formulation (e.g. ULV or EC), rate (which may vary with the pest controlled), and whether or not the crop can be harvested green or dry.

Grazing WHPs can vary depending upon whether or not the crop is grazed or cut for stock food before or after harvest.

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 is contained within the tables giving Directions for Use; on other labels the WHP appears separately below the Directions for Use.

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.

Where appropriate, growers are advised to contact the chemical manufacturer for advice on managing chemical residues in the crop or stock.

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 withholding periods 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 a suitable alternative, already registered, is not available and that safety and residue concerns are adequately addressed.

It is possible that permits may be granted during the course of the 2015–16 season. Consult the APVMA or your district horticulturist for this information. 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 all the details, conditions and limitations relevant to that permit, and must comply with the details, conditions and limitations before using that chemical.

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 may be required. Listed below are 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 Rd
North Ryde NSW 2113
P: (02) 9449 0111  F: (02) 9440 0297
Managing spray drift

Spray drift is the airborne movement of agricultural chemicals onto a non-target area with the potential for risk of injury or damage to humans, plants, animals, the environment or property.

For information on managing chemical application to avoid and minimise spray drift, farmers and applicators should read label directions carefully and consult with their district agronomist or horticulturist. See Further information at the end of this section.

Successfully managing spray drift will require a range of complementary strategies to be adopted, including:

» identifying sensitive areas
» establishing appropriate buffer zones
» property planning
» developing effective communication between growers, spray contractors and neighbours.

Sensitive areas
Sensitive areas are those where spray drift is likely to have the greatest adverse impact, such as:

» lakes, ponds and waterways
» wildlife habitats and wetlands
» neighbouring houses
» public roads (particularly those used by school buses)
» schools and other public amenities
» travelling stock routes and reserves
» organic and alternative farming systems.

The potential adverse impact will depend on the exact nature of the sensitive area in relation to the toxicity and formulation of the chemical.

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, all 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, such as transmitter towers.

Communication
Communicating with adjoining land users is critical in avoiding the conflict that can ensue from drift incidents. Communication can embrace:

» 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 chemical application
» an agreement on the conditions in which chemical application will not proceed or be discontinued
» a clearly defined process and timetable for resolving any conflict that arises during the spraying season
» an agreed process for recourse to regulatory action, if required.

Reducing pesticide spray drift
Spraying during the night and early morning is common, especially for reaching the target and to minimise the amount reaching off-target areas. This results in:

» maximum pesticide effectiveness
» reduced damage and/or contamination to off-target crops and areas.

In areas where a range of agricultural enterprises co-exist, conflicts can arise, particularly from pesticide use. 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 areas.

Some labels now carry spray drift management instructions including buffer zones. Read and follow all label instructions.
Managing spray drift

How to minimise spray drift problems

Before spraying

» Always check for susceptible crops in the area 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. Forms are available from www.dpi.nsw.gov.au/agriculture/farm/chemicals/general/records.

During spraying

» Always monitor meteorological conditions carefully and understand their effect 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.
» Spray when temperatures are less than 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 formulation of pesticide available.
» Maintain a downwind 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.

How many types of drift are there?

Sprayed pesticides can drift as droplets, as vapours or as particles.
Drumet drift is the easiest to control because, under good spraying conditions, droplets are carried down by air turbulence and gravity to collect on plant surfaces. Droplet drift is the most common cause of off-target damage from pesticide application.
Particle drift occurs when water and other pesticide carriers evaporate quickly from the droplet leaving tiny particles of concentrated pesticide. This can occur with herbicide formulations other than esters. Instances of this form of drift have damaged susceptible crops up to 30 km from the source.
Vapour drift is confined to volatile herbicides such as 2,4-D ester. Vapours can arise directly from the spray or evaporation from the herbicide-sprayed surfaces. Use of 2,4-D ester in summer can lead to vapour drift damage of highly susceptible crops such as tomatoes, sunflowers, soybeans, cotton and grapes. This 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.
Sensitive crops may be up to 10,000 times more sensitive than the crop being sprayed. Even small quantities of drifting herbicide can cause severe damage to highly sensitive plants.

What factors affect the risk of 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 applied. Volatility refers to the likelihood that the chemical will evaporate and become a gas. Esters volatilise (evaporate) more readily than amine formulations.
» Proximity of crops susceptible to the particular chemical being applied, and their growth stage.
» Method of application and equipment used. Aerial application releases spray at ~3 m above the target and uses relatively low application volumes, while ground rigs have lower release heights and generally higher application volumes, and a range of nozzle types. Misters produce large numbers of very fine droplets that use wind to carry them to their target.
» Amount of active ingredient applied – 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 during and shortly after application.

Use a low volatile formulation

Many ester formulations are highly volatile when compared with the non-volatile amine, sodium salt and acid formulations. Some low volatile ester formulations could have a proportion of high volatile esters present, so caution should be exercised when using these products.

The compromise between minimising drift and achieving ideal coverage

A significant part of minimising spray drift is equipment selected to reduce the number of small droplets produced. However, this in turn can affect target coverage, and therefore the possible effectiveness of the pesticide application.
This aspect of spraying 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 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 however, can lead to more striping, as the boom sways and dips below the optimum height.
- 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.
- Operate within the pressure range recommended by the nozzle manufacturer. Driftable fine droplet production increases as the operating pressure is increased. 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.

Aircraft application has an inherently greater risk than ground rig application due to a number of factors, including lower volume application, small droplet sizes, height of application, and turning and wing-tip vortices. An aircraft should not be used to apply herbicide in areas where highly susceptible crops are growing nearby.

**Size of the area treated**

When large areas are treated, relatively large amounts of active pesticide is applied and off-target risks increase due to the length of time taken to apply the herbicide. Conditions such as temperature, humidity and wind direction can fluctuate during spraying.

Applying volatile formulations to large areas increases the chances of vapour drift damage to susceptible crops.

**Weather conditions to watch out for**

**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 under low relative humidity conditions i.e. when Delta T (the difference between wet and dry thermometers) 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 under calm or still conditions. Under these conditions droplets are more likely to remain suspended in the air.
- Ideal safe wind speed is 7–10 km an hour. Leaves and twigs are in constant motion – a light breeze.
- 11–14 kph (moderate breeze) is suitable for spraying if using low drift nozzles or higher volumes application (80–120 L/ha). Small branches move, dust is raised and loose paper moving – a moderate breeze.

**Surface inversions**

**What are surface inversions?**

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

**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 into space 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 referred to as radiation cooling.

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

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

Radiation inversions also form over sloping terrain when air in contact with the ground is cooled by terrestrial radiation. The cooled layer remains quite shallow over the slope and is typically 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. Drainage inversions, once formed, 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 have caused substantial damage in the northern river valleys to cotton crops and to vineyards in the Murray Valley.

Radiation and drainage inversions typically begin in the evening at about sunset as 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.
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 and heavy cloud.
» There is continuous rain.
» Wind speed remains above 11 km/hr for the whole period between sunset and sunrise. Be mindful that established inversions can sometimes still occur when winds are in excess of 11 km/hr.

Source: APVMA. For more information on inversions, go to:

Where to find helpful meteorological information

Real time data needs to be collected in the paddock at the time of spraying. This can be done with:

» Handheld units that measure temperature, Delta T and wind speed
» On-farm weather stations – some can now be accessed by mobile phone.

Hourly data

» Forecasts are available from a number of websites for Delta T, wind speed etc. usually in three-hour blocks. Hourly data from the Bureau of Meteorology (BOM) weather stations including temperature, Delta T, wind speed and direction is available for the previous 72 hours from BOM. This data can help in planning spray activities and is useful for developing an understanding of the current daily patterns of meteorological conditions.

Meteograms™

Meteograms™ provide seven-day forecasts of:

» Temperature
» Relative humidity
» Delta T
» Rainfall
» Wind speed
» Wind direction.

Meteograms™ are very helpful in planning spray programs for periods of lowest drift risk and highest pesticide efficacy. Meteograms™ are mostly available by subscription. Some examples can be found at Weatherwise (http://www.weatherzone.com.au/models/meteogramdrill.jsp), or Spraywise (www.spraywisepredictions.com.au).

Source: M Scott, former Agricultural Chemicals Officer, NSW Department of Primary Industries, Orange

Figure 104. The relationship of air temperature and relative humidity to values of Delta T. Source: Bureau of Meteorology.

NEVER SPRAY DURING A LOW-LEVEL INVERSION

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 to be disposed of in an environmentally responsible manner.

**drumMUSTER**

AgStewardship Australia Limited has been established to develop and implement stewardship programs that reduce and manage waste for Australia’s agricultural sector. Its member organisations are the National Farmers’ Federation, CropLife Australia, Animal Health Alliance, the Veterinary Manufacturers and Distributors Association and the Australian Local Government Association.

It is responsible for managing two of the most successful voluntary product stewardship programs in Australia: drumMUSTER® and ChemClear®, which collect and dispose of used agricultural chemical containers and unwanted crop protection and animal health chemicals. Agsafe Limited, who previously managed these programs, has been contracted by AgStewardship to continue delivering them on its behalf.

**Cleaning containers for collection**

When rinsing chemical containers, the personal protective equipment (PPE) specified on the label for application and/or mixing and 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 the rinsing process.

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% (1 L per 5 L) of container volume**
3. **replace cap and shake vigorously for one minute**
4. **remove cap, invert and drip drain into mixing tank for 30 seconds**
5. **repeat twice**
6. **wash cap separately and replace on container.**

Triple rinsing is only suitable for small containers, up to 20 L. Rinsing is most effective 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 the reason for rinsing during mixing and loading. If rinsing is done during mixing and loading, the rinsate can be emptied into the spray or mixing tank of the application equipment, where it can be disposed of for its desired application. Using the rinsate in this way avoids the necessity for having to dispose of the container residues separately (see Disposal of rinsate or dilute chemical on page 81 below).

An alternative to manually triple rinsing small containers is a pressure rinsing nozzle. There are two main types. One type 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 pressure rinsing probe either through container opening or through pierced base of the container (depending upon type of nozzle)
4. invert container over 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 cap in clear rinse water from container
6. turn off water, remove probe and drip drain container into mixing tank for 30 seconds
7. replace lid on 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 options 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 page 81 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.


ChemClear
ChemClear is the national Industry stewardship program set up under the Industry Waste Reduction Scheme (IWRS). The program collects and disposes of unwanted agricultural and veterinary (agvet) chemicals. The ChemClear and drumMUSTER programs are funded through a joint levy under the IWRS, which is applied by participating manufacturers of agvet chemicals and passed on to the chemical user at the point of sale. There are two categories of agvet chemicals ChemClear® collects:

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

Group 2 chemicals are products 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.

Visit www.chemclear.com.au for information
Register for the program @ 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. 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. The pit should be a metre deep, lined with plastic sheeting over which has been spread hydrated lime, and any wastes 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.
When trying to achieve adequate pest and disease control it is important to understand the significance of timing, calibration and coverage. Each of these are individually essential and if any one of these is missing the strategy of pest and disease control will fail.

**Coverage** is about ensuring that your spray application covers the whole target area, including the high production front at the tops of the trees.

**Calibration** is making sure that once you achieve this coverage you calibrate to ensure the right amount of product is hitting the target.

**Timing** is understanding the life cycle of the pest and identifying the correct time to spray in order to suffer the least amount of product loss.

Where all three elements align, we achieve good control and production. If any of the three are missing or not effective, then there are potential threats to the system not working.

We need to physically check our spray coverage to ensure we are achieving an even coverage throughout the bush. This is where our production front is and this is what needs to be covered. Blueberries, raspberries and blackberries are not huge plants in general so spray equipment should be targeted at achieving a good overall coverage on both leaf surfaces. Water sensitive paper placed on upper and lower leaf surfaces, inside and on the outside of the bush will allow a check on how effective your spray equipment is at achieving a thorough, even coverage.

Check out orchards and look for pest and disease activities. No one knows the orchard better than the person working the orchard. A pest scout or consultant will also complement this knowledge.

Finally we need to ensure we calibrate the spray equipment. Just as we check other machinery, (e.g. your car every 10,000 km and tractor every 1000 hours) we also need to check our sprayer every year. When we calibrate we can be sure that the right amount of chemistry is hitting our target pest.
Most pesticide labels quote use rates in mL (millilitres) or g (grams) of product per 100 L (litres). Exceptions do occur, such as the rates of chemical thinners and diphenylamine (DPA), which are commonly expressed in terms of parts per million (ppm). If the dosage required is incorrectly calculated, costly mistakes can be made in the orchard or packing shed.

Dipping rates for postharvest treatment for Queensland fruit fly are quoted as milligrams per litre (mg/L), the equivalent of ppm.

**Standard formula – amount per 100 L**

To calculate the amount of product (in litres or kilograms) per 100 L of spray or dip, given the rate or concentration in ppm or mg/L, use the following formula:

\[
\text{Required amount of product for 100 L} = \frac{\text{dip strength (ppm or mg/L) or kg}}{\text{product strength (g/L or g/kg) \times 10}}
\]

**For a tankful**

Multiply the figure obtained from your standard formula (above) by your tank size and ÷ 100

**Some examples**

**Spraying thinners**

How much carbaryl product (product strength 500 g/L) is required per 100 L of water if the concentration rate for Granny Smith apples is 1000 ppm (or mg/L)?

\[
\text{Required amount of product (in L)} = \frac{1000 \text{ ppm or mg/L}}{500 \text{ g/L} \times 10} = 0.2 \text{ L per 100 L}
\]

To convert litres to mL, multiply by 1000. In this case the amount of product is 200 mL/100 L.

**Fruit dipping – DPA (diphenylamine)**

A grower needs to dip Red Delicious apples at 2000 ppm using a 310 g/L DPA product in an 1100 L dipping tank. The quantity (in litres) of DPA needed to give the required dip concentration is:

\[
\text{Required amount of product (in L)} = \frac{2000 \text{ ppm or mg/L}}{310 \text{ g/L} \times 10 \times 100} = 7 \text{ L of DPA product per tankful}
\]

**Field spraying for Queensland fruit fly**

**Dilute**

An orchardist needs to spray orchard trees for Queensland fruit fly using Product A. The label rate is 75 mL of Product A per 100 L. The spray is to be made up in a 1500 L vat.

\[
\text{Required amount of Product A (in L)} = \frac{75 \text{ mL} \times 1500 \text{ L}}{100 \text{ L}} = 1125 \text{ mL (1.125 L) product in the vat. This is the dilute spray mix.}
\]

**Concentrate**

If the same grower, using the same equipment but correctly set up for concentrate spraying wanted to control fruit fly, then the calculation is given below.

For this example, the sprayer puts out 2000 L/ha dilute to wet the trees ‘to the point of run off’ (see Timing, calibration and coverage for berries on the previous page). Re-nozzled and adjusted for concentrate spraying, the 1500 L sprayer vat now applies 500 L/ha. The concentration factor in this example is therefore 2000 ÷ 500 or 4×.

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

\[
\text{Required amount of Product A (in L)} = \frac{75 \text{ mL} \times 1500 \text{ L} \times 4}{100 \text{ L}} = 4500 \text{ mL (4.5 L) product in the vat.}
\]

Additional information on concentrate spraying might be available on the label.
Documents are required by quality assurance programs to provide evidence that the produce is safe and of acceptable quality. Types of documents include records of pesticide applications, orchard sprayer calibration and a spray diary.

How to fill out your pesticide application record

Records must be kept for three years. Records should be made within 24 hours of the application. Records must be in English.

General information

Operator
The operator, or person applying the pesticide, must fill in their contact details. If the operator is not the owner, e.g. a contractor or employee, then the owner’s details also have to be filled in. In the case of a contractor, one copy of the record should be kept by the applicator and another given to the owner.

Date of application, start time, finish time
You must record the date, the time of the day you started and the time when you finished.

Crop details

Crop sprayed
Adding details such as crop variety and growth stage are often important for QA schemes, but might also be necessary to positively identify the area treated.

Block/area and size of block sprayed
Identify the block/area and order of treatment (if there is more than one) in the ‘Block/area’ and ‘Size of block sprayed’ boxes on the form. This should be filled in before starting application, along with the residential address. If using a contractor or an employee, this information should also be given to them before they start the job.

Product/application details

Pest/disease targeted
It is desirable to identify the targeted pest or disease. It is helpful to provide as much detail about the pest or disease as possible, e.g. for a grub: 3rd instar/10 mm.

Equipment used
As a minimum, you have to fill in what equipment you used. Specifying the settings (e.g. nozzle type and angle, pressure) used will help identify the equipment used. The nozzle type will usually include the angle. With pressure, the reading should be as close to the nozzle as possible.

Other comments
Rainfall should be recorded for the 24 hours before and the 24 hours after application, unless a different figure is given in the restraints or critical comments section of the label. Rainfall before or after application can affect efficacy. Temperature and relative humidity should also be recorded, particularly if either or both are referred to in the restraints or critical comments sections of the label. Temperature and relative humidity can affect efficacy, increase the risk of off-target drift or can damage the host (e.g. phytotoxicity) or a combination of all three. If there are ‘sensitive areas’, either on the property or land adjoining, these should be identified in advance, and marked on a sensitive areas diagram that should be appended to the Pesticide application record sheet, together with any precautions or special instructions. When using a contractor or giving the job to an employee, this section should be filled in and given to the person doing the application before the job starts. The property map with sensitive areas marked should be shown to them, and the job fully discussed.
### Pesticide Application Record Sheet
(To be completed in English within 24 hours of spraying and kept for 3 years)

<table>
<thead>
<tr>
<th>General Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator: (See note at bottom of sheet)*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of application:</th>
<th>Start time:</th>
<th>Finish time:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Crop Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop sprayed:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product/Application Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pest/Disease targeted (not compulsory):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product used (full trade name):</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Amount of concentrate used:</th>
<th>Total quantity of spray applied (in ha or m²):</th>
<th>Total area of application:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Weather Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Did weather conditions change during spraying?</th>
<th>No</th>
<th>Yes (give details):</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Other comments:</th>
</tr>
</thead>
</table>

* Operator: If it is the property owner you need to record name, address and contact details, for an employee you need to record name and employer details and for a contractor you need name, address and contact details. On this record you can record the name only, as long as you have the other details recorded elsewhere.
Resistance in an insect, mite or disease to a specific chemical has occurred when the chemical no longer provides the control it did previously. Populations of pests and diseases that are repeatedly sprayed with a particular chemical can develop resistance to it. All populations contain a very small number of individuals that are resistant to a given pesticide. Continued use of the pesticide kills susceptible individuals, but in doing so selects a strain that is increasingly composed of resistant forms. Once resistant forms reach a critical proportion of a population, lack of control ultimately renders the chemical useless.

**Resistance management**

Managing resistance for all pesticides is now an important consideration when choosing a control strategy. One strategy used in resistance management is rotating chemical groups so that the weed, fungus, insect or mite is not being continually treated by the same type of chemical. Repeated treatment could lead to the organism becoming resistant to that chemical group. In the past, it has often been difficult for growers to distinguish between chemical groups and their different modes of action, a factor important in successful rotation. An identification scheme has been set up for both herbicides and fungicides. From July 2001, all registered pesticides have an activity group identification symbol on the label, helping growers to choose a product from a different chemical activity group when seeking to rotate chemicals in a program.

**Miticide resistance: a case study from the apple industry**

Mites are particularly successful in developing pesticide resistance and have overcome virtually every miticide produced since the 1950s. While a few older miticides are still effective and have their place (e.g. propargite) there have been several new miticides released (e.g. chlorfenapyr, bifenazate). Each of the newer products has a specific resistance warning on the label. None must be used more than once in a season. Also, avoid consecutive applications of the same chemical group between seasons.

Anti-resistance strategy guidelines are based on the integrated mite control and miticide rotation used. They are:
- adopt integrated mite control (IMC) based on predatory mites
- do not use a miticide from the same chemical group more than once in a season
- alternate with miticides from another group (see below) both within and between seasons.

An enhancement to this strategy for managing European red mite on apples is using horticultural mineral oil (HMO) just after full bloom. Applying HMO at this time is only recommended when European red mite eggs are observed in moderate to high numbers on the limbs, laterals or spurs during winter.

Miticides available for the apple industry in 2011–12 for a rotation program, arranged in groups, are:
- Group UN (unknown) bifenazate (Acramite®)
- Group 6 avamectin (many products)
- Group 21A tebufenpyrad (Pyranica®)
- Group 108 etoxazole (Paramite®)
- Group 12B fenbutatin oxide (Torque®)
- Group 13 chlorfenapyr (Secure®)
- Group 12C propargite (Omite®)

Abamectin is most effective early in the season and should not be used on apples later than six weeks after petal fall. It is compatible with integrated mite control, but in keeping with the overall aim of limiting miticides use, abamectin should not be used within its limited six-week application period (apples only) unless mites are actually present and pose a potential threat. The restrictions on timing do not apply to pears.

Bifenazate (Acramite®) is a miticide that can be used as a knockdown in both IMC and non-IMC programs. It also has residual activity. Bifenazate is claimed to be effective against both two-spotted and European red mites and can be used on a wide range of pome and stone fruits crops. Both two-spotted mite and European red mite are resistant to tebufenpyrad (Pyranica®) in some districts. Fenbutatin oxide effectiveness is limited by its poor performance in cool conditions. It can be applied to pears, whereas propargite cannot be used on pears until after harvest.
Propargite has been consistently effective against two-spotted mite for many years. It is less effective against European red mite. Low levels of resistance in two-spotted mite have been detected, but so far, its field performance has not been significantly reduced. Ideally, if IMC is operating efficiently, at the most only one IMC rate spray should be required in the season. For non-IMC situations, the use of propargite in the ‘2 sprays at 7 days apart’ program is acceptable within the strategy.

Chlorfenapyr (Secure®) is a miticide registered for use against two-spotted mite on apples, pears and peaches. It is ineffective against European red mite.

If a commercial consultant operates in your area, consider engaging the consultant to monitor the orchard for pest and predatory mites and to guide your product choice.

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. Biological control on page 66 has a list of suppliers.

Insecticides
Unfortunately, the berry industry in NSW and Qld relies heavily on chemistry of the same groups, being 1B, so the option of chemical rotation is limited. The option is there however and must be used to prevent resistance to what few chemicals are available to industry. In the early stages of plant production for pre flowering and flowering pests, options are limited to a range of 1A products. There should be a conscious decision at the later stages of berry development to use alternative options to 1A that are available with short WHPs.

A typical scenario could be to spray thrips early with a 1A product at flowering, but avoid bees foraging.

Continue monitoring regularly for pests at this critical stage, there might be another requirement for a product to be used again later during flowering. Then, just before harvest, there is an opportunity to use a different chemical group, say 3A.

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

Ideally, the best way forward for industry is to use available researchers to continually screen new chemical formulations as they become available. Not only will the researchers screen the new formulations’ effectiveness, but will also identify ways that the new chemistry can be incorporated into the spray program system to achieve better 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 over and over again, 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. Unfortunately, in blueberries there is a limited choice of products available to prevent rust, which is the industry’s main fungal concern for interstate market access. Rosalie Daniel Plant Pathologist at NSW DPI has developed a berry Anthracnose and Botrytis control management strategy advising which products are available to industry that maintain resistance.

### Table 12. Anthracnose and Botrytis management strategy

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

A similar management control strategy for blueberry rust control which would also comply with Interstate Certification Assurance (ICA31).

### Table 13. 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>Spray strategy 1</td>
<td>Mancozeb Tilt</td>
<td>Mancozeb Pristine*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray strategy 2</td>
<td>Chlorothalonil (Not for ICA 31)</td>
<td>Mancozeb Tilt</td>
<td>Pristine*</td>
<td></td>
</tr>
<tr>
<td>Spray strategy 3</td>
<td>Mancozeb Chlorothalonil (Not for ICA 31)</td>
<td>Pristine* Tilt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray strategy 4</td>
<td>Mancozeb Mancozeb Pristine* Tilt</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Alternative products should be used when these special advantages are not really required.

Where a fungus develops resistance to a particular fungicide, it will often also be resistant to related chemicals. It is therefore important to select a disease control program to ensure that the fungicides come from different groups. See Table 14 below.

If DMI fungicides are used alone, limit their use to a total of four applications, then follow with a protectant fungicide within seven days. If more than four DMI applications are required, subsequent sprays should be mixed with a protectant fungicide that has a different mode of action to the DMIs. See labels for anti-resistance strategies.

Never rely solely on one type of fungicide for whole season disease control, no matter how effective it seems; use at least two fungicides with different modes of action.

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

Table 14. Fungicide groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Chemical class</th>
<th>Common name: example trade name*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4+M1</td>
<td>Metalaxyl + copper hydroxide</td>
<td>Ridomil Gold Plus: Ridomil®</td>
</tr>
<tr>
<td>33</td>
<td>Phosphonic acid</td>
<td>Agrifos®</td>
</tr>
<tr>
<td>9,12</td>
<td>Cyprodinil + Fludioxonil</td>
<td>Switch: Switch®</td>
</tr>
<tr>
<td>9</td>
<td>Pyrimethanil</td>
<td>Scala: Scala®</td>
</tr>
<tr>
<td>7,11</td>
<td>Boscalid + Pyroclastrobin</td>
<td>Pristine: Pristine®</td>
</tr>
<tr>
<td>2</td>
<td>Dicarboximide</td>
<td>Iprodione: Rovral®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Propiconazole: Sumiscllex®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fludioxonil: Vision®</td>
</tr>
<tr>
<td>M1</td>
<td>Inorganic Copper fungicides: Kocide®</td>
<td></td>
</tr>
<tr>
<td>M2</td>
<td>Inorganic Sulfur as polysulfide: Lime Sulfur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulfur (elemental): Thiovit®</td>
<td></td>
</tr>
<tr>
<td>M3</td>
<td>Dithiocarbamate</td>
<td>Mancozeb: Dithane®</td>
</tr>
<tr>
<td>M4</td>
<td>Phthalimide</td>
<td>Captan: Orthocide®</td>
</tr>
<tr>
<td>M5</td>
<td>Chloronitri le</td>
<td>Chlorothalonil: Bravo®</td>
</tr>
</tbody>
</table>

Table 15. Insecticide and miticide groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Chemical class</th>
<th>Common name: example trade name*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Carbamate</td>
<td>Carbaryl: Bugmaster Flowable®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methomyl: Lannate L®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pirimicarb: Aphidev®</td>
</tr>
<tr>
<td>1B</td>
<td>Organophosphate</td>
<td>Azinphos-methyl: Gusathion®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chlorpyrifos: Loriban®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diazinon: Dazol®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fenithion: Lebaycid®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Malathion: Fyfan®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methidathion: Supraflion®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Omethoate: Foliom®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prothiofos: Tokuthion®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trichlorfon: Dipex®</td>
</tr>
<tr>
<td>3</td>
<td>Pyrethroid</td>
<td>Alpha-cypermethrin: Fastac Duo®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bifenthrin: Talstar®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tau-fluvalinate: Mavrik Aquafloat®</td>
</tr>
<tr>
<td>4</td>
<td>Neonicotinoid</td>
<td>Imidacloprid: Confidor®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiacloprid: Calypso®</td>
</tr>
<tr>
<td>5</td>
<td>Spinosyn</td>
<td>Spinosad: Success 2®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spinetoram: Delegate®</td>
</tr>
<tr>
<td>6</td>
<td>Avermectin</td>
<td>Abamectin: Vertimec®</td>
</tr>
<tr>
<td>7B</td>
<td>Juvenile hormone mimic</td>
<td>Fenoxycarb: Insegar®</td>
</tr>
<tr>
<td>9B</td>
<td>Feeding blocker</td>
<td>Pyrethrin: Chess®</td>
</tr>
<tr>
<td>10A</td>
<td>Tetratizine</td>
<td>Clorfenapyr: Apollo®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiazylazine: Calibre®</td>
</tr>
<tr>
<td>10B</td>
<td>Microbial</td>
<td>Etoxazole: Paramite®</td>
</tr>
<tr>
<td>11</td>
<td>Microbial</td>
<td>Bacillus thuringiensis: DiPe®</td>
</tr>
<tr>
<td>12B</td>
<td>Organotin</td>
<td>Fenbutatin oxide: Torque®</td>
</tr>
<tr>
<td>13</td>
<td>Pyrethroid</td>
<td>Cypermethrin: Fastac Duo®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bifenthrin: Talstar®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methomyl: Lannate L®</td>
</tr>
<tr>
<td>16</td>
<td>Thiaziadizine</td>
<td>Buprofezin: Applaud®</td>
</tr>
<tr>
<td>1B</td>
<td>Diacyhydrazin</td>
<td>Methoxyfenozide: Prodigy®</td>
</tr>
<tr>
<td>1B</td>
<td>Mite growth inhibitor</td>
<td>Tebufenpyrad: Pyramic®</td>
</tr>
<tr>
<td>22A</td>
<td>Oxadizine</td>
<td>Indoxacarb: Avatar®</td>
</tr>
<tr>
<td>28</td>
<td>Diamicide</td>
<td>Chlorantraniliprole: Altacor®</td>
</tr>
<tr>
<td>UN</td>
<td>Neonicotinoid</td>
<td>Bifenazate: Acramite®</td>
</tr>
<tr>
<td>1</td>
<td>贸易名称中包含通用化学名称者未列出。来源：Infest Pest July 2011 and CropLife Australia.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>贸易名称中包含通用化学名称者未列出。来源：Infest Pest July 2011 and CropLife Australia.</td>
<td></td>
</tr>
</tbody>
</table>

* Example only. Other products registered.
Key DPI contacts

Regulatory staff
Guide users who require advice on intrastate or interstate movement of fruit should contact the nearest Regulatory Specialist, Plants.
SIR: Senior Inspector, Regulatory
RS(P): Regulatory Specialist (Plants)
RS (A): Regulatory Specialist (Animals)

Berry
Elizabeth Yeatman RS(P)
p: 4464 6006 m: 0411 139 585 f:4464 2113
Berry District Office
13 Schofields Lane BERRY
(PO Box 63 Berry 2535)

Coffs Harbour
Anne Webster (SIR)
p: 6650 3111 m: 0427 102 253 f: 6651 2780
Coffs Harbour District Office (Agriculture)
Suite 5, Level 1, City Square
76 Harbour Drive COFFS HARBOUR
(PO Box 530 Coffs Harbour 2450)

Dubbo
Ross Taylor A/SIR
p: 6881 1273 m: 0429 042 892 f: 6881 295
Dubbo District Office
Cnr Hampden and Cobra Streets DUBBO
(PO Box 865 Dubbo 2830)

Grafton
Stephen Green
p: 6640 1618 m: 0438 977 714 f: 6644 7251
(Private Mail Bag 9002 Grafton 2460)

Griffith
David Sinclair
p: 6960 1355 m: 0412 139 258 f: 6963 0255
217 Murray Road HANWOOD
(PO Box 1087 GRIFFITH NSW 2680)

Gunnedah
Mick Rankmore (RS) Apiaries
p: 6741 8374 m: 0402 078 963 f: 6742 4018
NSW Government Offices
35–37 Abbott Street GUNNEDAH NSW
(PO Box 546 Gunnedah 2380)

Hay
Dean Whitehead RS(Animals)
p: 6990 1871 m: 0427 311 441 f: 6993 3196
Hay District Office
177 Lachlan Street HAY
(PO Box 393 Hay 2711)

West Kempsey
Michael Cagnacci
p: 6563 6801 m: 0427 102 706 f: 6562 5614
Kempsey District Office
27–29 Elbow Street WEST KEMPSEY
(PO Box 3141 Kempsey 2440)

Orange
Brett Kerruish
p: 6391 3685 m: 0427 239 569 f: 6391 3336
Department of Primary Industries – Head Office
161 Kite Street ORANGE
(Locked Bag 21 Orange 2800)

Sydney Markets
Rob Bowman (SIR) m: 0411 139 579
Mick Thompson m: 0409 309 532
Kamal Basta m: 0411 139 674
Ala Samara m: 0411 139 679
p: 9735 9601 (mornings only) f: 9735 9630
Flemington Markets Office
Shop 1, Market Plaza SYDNEY MARKETS
(PO Box 1 Sydney Markets 2129)

Tocal
David Deane
p: 4939 8944 m: 0411 108 961 f: 4939 8961
Genevieve Leonard RS(P)
p: 4939 8955 m: 0427 208 615 f: 4939 8961
Tocal Agricultural Centre
Tocal Road PATERSON
(Tocal Road Paterson 2421)

Tumut
Peter Treloar
p: 6941 1403 m: 0427 012 482 f: 6947 4149
Tumut District Office
64 Fitzroy Street TUMUT
(PO Box 3 Tumut 2720)
Horticultural contacts
Below is a list of Agriculture NSW, development officers and leaders working in Horticulture.

Blueberries
Phillip Wilk, Development Officer – Blueberries
e: phillip.wilk@dpi.nsw.gov.au
p: 0427 022 579 m: 0427 013 465 f: 06972 3839
West Wyalong District Office
40 Church Street WEST WYALONG
(PO Box 378 West Wyalong 2671)

Melinda Simpson, Development Officer – Blueberries
e: melinda.simpson@dpi.nsw.gov.au
p: 0411 139 567 m: 0447 081 765 f: 06972 3839

NSW Department of Primary Industries
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2480

Citrus
Andrew Creek, Development Officer – Citrus
e: andrew.creek@dpi.nsw.gov.au
p: 0428 934 952 m: 0428 934 952 f: 06951 2692
NSW Department of Primary Industries
Wollongbar Primary Industries
1243 Bruxner Highway WOLLONGBAR NSW 2477

Temperate Fruits
Kevin Dodds, Development Officer – Temperate Fruits
e: kevin.dodds@dpi.nsw.gov.au
p: 0427 918 315 m: 0429 785 259 f: 0427 918 315
NSW Department of Primary Industries
161 Kite Street ORANGE NSW 2800

Southern Horticulture Leader
Myles Parker, Leader, Southern Horticulture
e: myles.parker@dpi.nsw.gov.au
p: 0419 217 553 m: 02 6391 3155 f: 02 6391 3155
NSW Department of Primary Industries
Orange Agricultural Institute
1447 Forest Road ORANGE NSW 2800
Northern Horticulture Leader
Mark Hickey, Leader, Northern Horticulture
e: mark.hickey@dpi.nsw.gov.au
p: 6626 1277 m: 0427 401 474 f: 6628 1744
NSW Department of Primary Industries
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2477

Director Horticulture
Dr Shane Hetherington, Director Horticulture
e: shane.hetherington@dpi.nsw.gov.au
p: 6391 3860 m: 0409 314 894 f: 6391 3605
NSW Department of Primary Industries, 161 Kite Street
ORANGE NSW 2800

Viticulture Leader
Greg Dunn, Leader, Viticulture
e: gregory.dunn@dpi.nsw.gov.au
p: 6933 2108 m: 0427 161 510 f: 6938 1809
NSW Department of Primary Industries
National Wine and Grape Industry Centre
Pine Gully Road WAGGA WAGGA NSW 2650

Viticulture
Darren Fahey, Development Officer – Viticulture
e: darren.fahey@dpi.nsw.gov.au
p: 6933 2961 m: 0457 842 874 f: 6933 2940
NSW Department of Primary Industries
National Wine and Grape Industry Centre
Pine Gully Road WAGGA WAGGA NSW 2650
Adrian Englefield, Development Officer - Viticulture
e: adrian.englefield@dpi.nsw.gov.au
p: 633 2720 m: 0428 324 099 f: 6933 2940
NSW Department of Primary Industries
National Wine and Grape Industry Centre
Pine Gully Road WAGGA WAGGA NSW 2650

Sub-tropical Bananas
Matt Weinert
Development Officer – Subtropical Bananas
e: matt.weinert@dpi.nsw.gov.au
p: 6626 1352 m: 0438 644 136 f: 6628 1744
NSW Department of Primary Industries
Wollongbar Primary Industries Institute
1243 Bruxner Highway WOLLONGBAR NSW 2477

Contacts
Phillip Wilk
Melinda Simpson
Steven Falivene
Andrew Creek
Jeremy Bright
Jonathan Lidbetter
Kevin Dodd
Myles Parker
Shane Hetherington
Mark Hickey
Greg Dunn
Darren Fahey
Matt Weinert
Adrian Englefield
Central Tablelands LLS
Karen O’Malley
Senior Land Services Officer (Horticulture)
e: karen.omalley@lls.nsw.gov.au
p: 1300 795 299 p: 6339 4906 m: 0428 103 665
w: www.centraltablelands.lls.nsw.gov.au
66 Corporation Avenue (PO Box 20)
BATHURST NSW 2795

Coffs Harbour LLS
Julie Dart
Senior Land Services Officer
NC Operations Unit (South)
p: 6650 9406 m: 0427 007 501

Greater Sydney LLS
Leigh James
Senior Land Services Officer (Horticulture)
e: leigh.james@lls.nsw.gov.au
p: 4724 2117 m: 0412 429 418 f: 4724 2198
w: www.greatersydney.lls.nsw.gov.au
Level 4, 2–6 Station Street (PO Box 4515)
PENRITH NSW 2750

Riverina LLS
Tammy Galvin
Fruit Fly Campaign Coordinator Senior Land Services Officer (Projects)
e: tammy.galvin@lls.nsw.gov.au
p: 02 6951 2705 m: 0427 221 651 f: 02 6951 2568
w: www.riverina.lls.nsw.gov.au
Yanco Agricultural Institute (Private Mail Bag) 2198
Irrigation Way-East
YANCO NSW 2703

Riverina LLS
Justin Vardanega
Senior Land Services Officer (Horticulture)
e: justin.vardanega@lls.nsw.gov.au
p: 02 6960 1316 m: 0429 450 852 f: 02 6963 1308
w: www.riverina.lls.nsw.gov.au
RLLS Murray Rd (PO Box 1087)
GRIFFITH NSW 2680

Western LLS
Gregory Moulds
Senior Land Services Officer (Agribusiness)
e: gregory.moulds@lls.nsw.gov.au
p: 03 5021 9444 m: 0427 311 445 f: 03 5021 1308
w: www.western.lls.nsw.gov.au
32 Enterprise Way (PO Box 363)
BURONGA NSW 2739

Karen O’Malley
Gregory Moulds
Leigh James
Tammy Galvin
Julie Dart