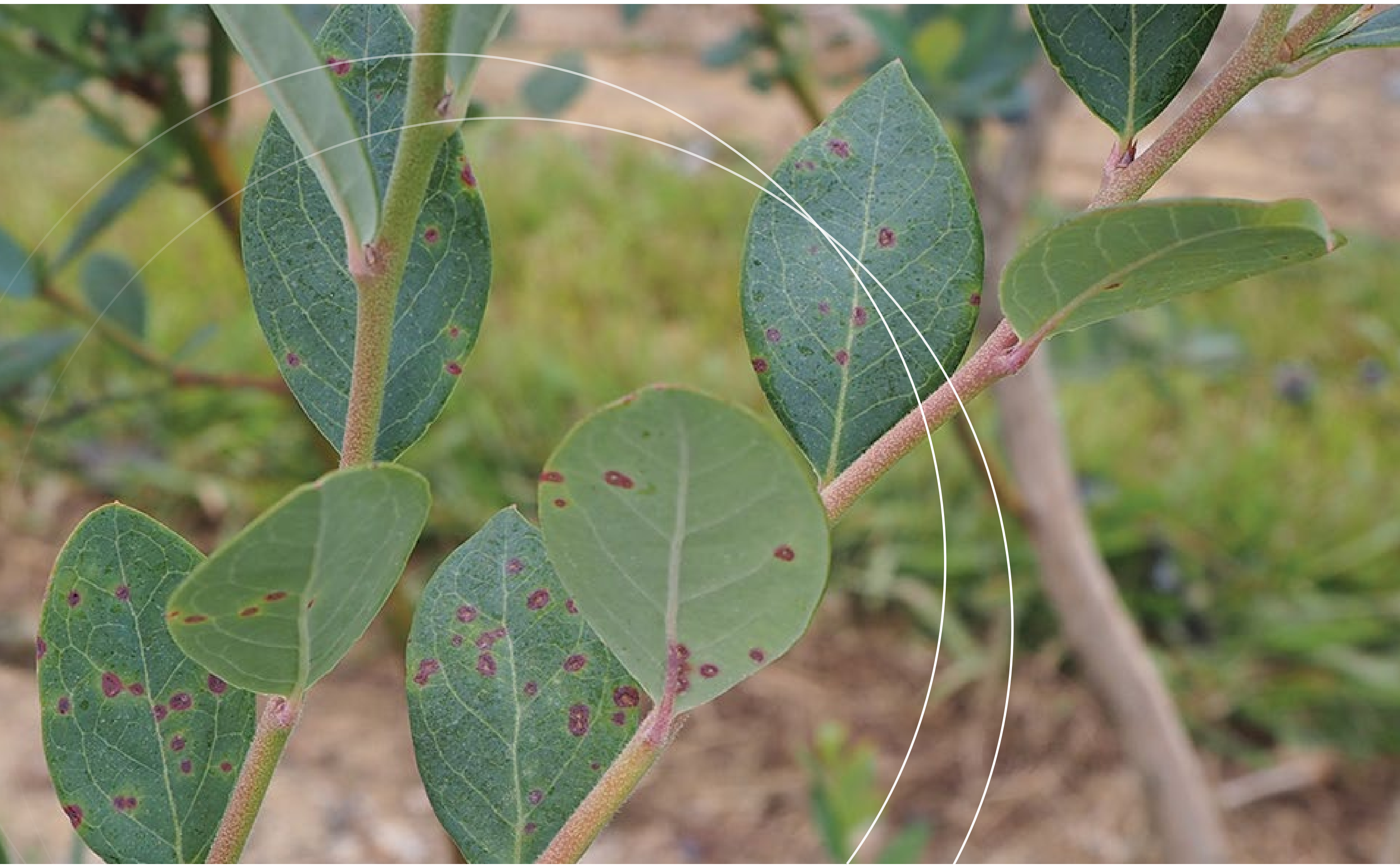
Department of Primary Industries

Department of Regional NSW

Managing blueberry rust

NSW DPI MANAGEMENT GUIDE



Melinda Simpson

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Image acknowledgements

Unless otherwise stated, the images in this guide have been sourced from NSW DPI.

Cover photo

Blueberry rust on blueberry leaves. Rosalie Daniel, NSW DPI.

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Introduction

Blueberry rust is a disease caused by *Pucciniastrum minimum*, a pathogen formerly known as *Thekopsora minima*. The fungus primarily infects leaves, causing reduced plant vigour and fruit set. When fruit is infected, marketability can be affected. Blueberry rust thrives in warm, wet conditions, especially when there are extended periods of leaf wetness (such as dewy conditions) and susceptible host tissue is present.

Managing blueberry rust requires an integrated approach (Figure 1) involving:

- scouting of blueberry plants to detect early infections
- monitoring weather conditions to identify when they are conducive to the infection and disease symptom development
- cultural measures such as pruning
- targeted application of fungicidal sprays
- genetic resistance and planting less susceptible varieties.

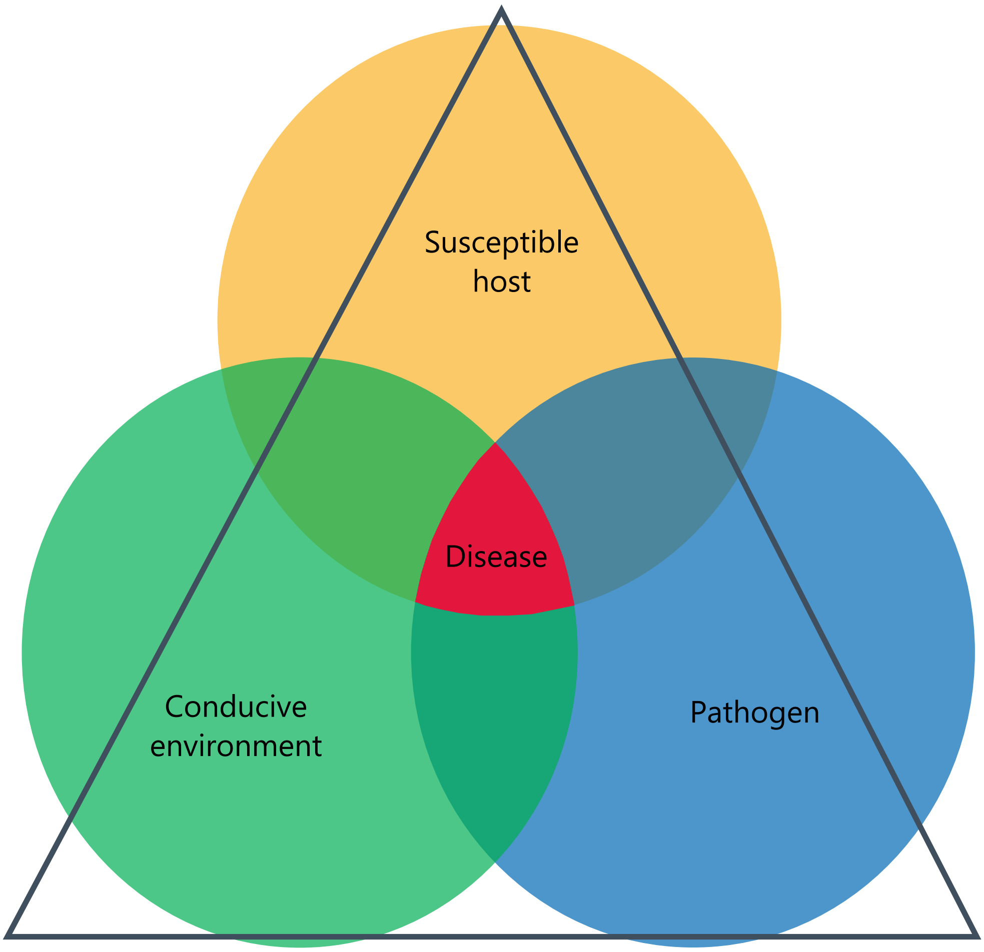

Figure 1. The disease triangle illustrates the phenomenon of plant disease as the interior space with the 3 essential factors: susceptible host, favourable environment for disease, and pathogen. If any one of these is missing, the area occupied by disease collapses to zero. Less dramatic alterations in any factor change the size of the central disease area, which indicates disease intensity (incidence or severity).

The disease and its cycle

Pucciniastrum minimum is a heteroecious (passes through different life cycle stages on alternate and often unrelated hosts) rust fungus; it needs 2 different hosts to complete its full life cycle and **can only reproduce on a living host**. The aecial stage is completed on hemlock (*Tsuga* spp., Pinaeace), while urediniospores and teliospores are formed (Figure 2) on Ericaceae plants such as *Vaccinium* spp. (blueberry). In Australia, the disease is spread by the urediniospores (bright yellow–orange spores), and research needs to confirm the role, if any, of teliospores on disease development.

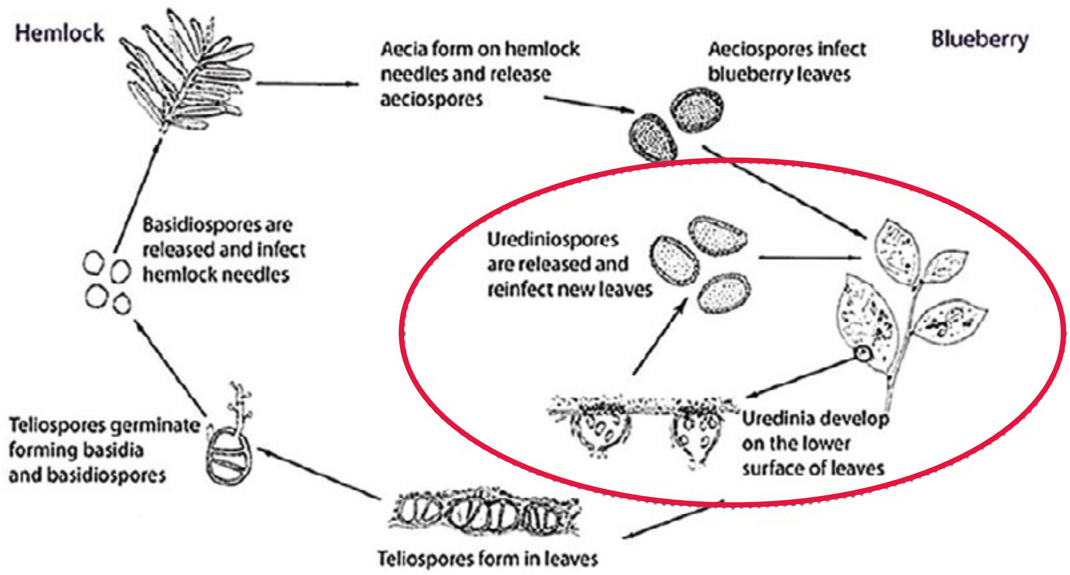

Figure 2. Blueberry rust life cycle. The red circle indicates the spore stage that causes disease in blueberries.

Survival

The blueberry rust fungus survives primarily on and in infected leaves that remain on the plant after pruning (Figure 3). In the evergreen system, where leaves are continuously present, they can be infected with *P. minimum* throughout the year, but this can be difficult to detect. When conditions become conducive (warm and moist), the fungus is stimulated to form pustules and sporulate to reinfect.

Research in Australia found infected leaf debris on the orchard floor is unlikely to be a major source of **re-infection** as spore survival is generally less than 6 weeks, depending on agronomic and environmental factors practised in the orchard (Rosalie Daniel, pers comm.). It is likely that sporulation can be initiated from infected leaves 2 weeks after they are placed on the orchard floor. After this time, too many other fungi were present on the leaves to effectively distinguish the rust fungus.

Figure 3. Leaves remaining on the plant after pruning (highlighted in red circle) can be a source of blueberry rust survival. Photo: George Mittasch, Norco.

First infection

The rust fungus, *P. minimum*, is biotrophic. That means it will **only infect living plant tissues**. Spores require moisture for germination and infection. If moisture is present, infection can begin at any plant growth stage from when leaves first emerge. Younger leaves are more susceptible, possibly because older leaves have thicker cuticles, making it more difficult for the fungus to penetrate.

Latent period

Following infection, the fungus colonises the leaf. The time between infection and when symptoms appear is known as the latent period. The length of this depends largely on temperature, but is generally between 10 and 21 days. At 23 °C, yellow pustules begin to appear on infected leaves (Figure 4) after 10 days. Thereafter, the small yellow lesions appear on the upper surface of the leaf.

Figure 4. Yellow pustules on the underside of a blueberry leaf. These appear approximately 10 days after the infection.

Spread

Spores produced in pustules on leaves are the main infective propagule of blueberry rust in the evergreen production system. In certain climates they can be in the air all year (Figure 5). Rain, water-splash, air currents, insects and humans can spread spores to infect new plant tissues. Pustules will continue to develop and spores will be released as long as conditions are favourable. There can be many infection cycles in a production season.

The disease cycle continues as long as conditions are favourable (warm, moist) and susceptible foliage is available to infect. Initially only a few pustules might be present, but as the season progresses and if control measures are inadequate, then rust urediniospore numbers can increase significantly, and the rust spreads throughout the orchard.

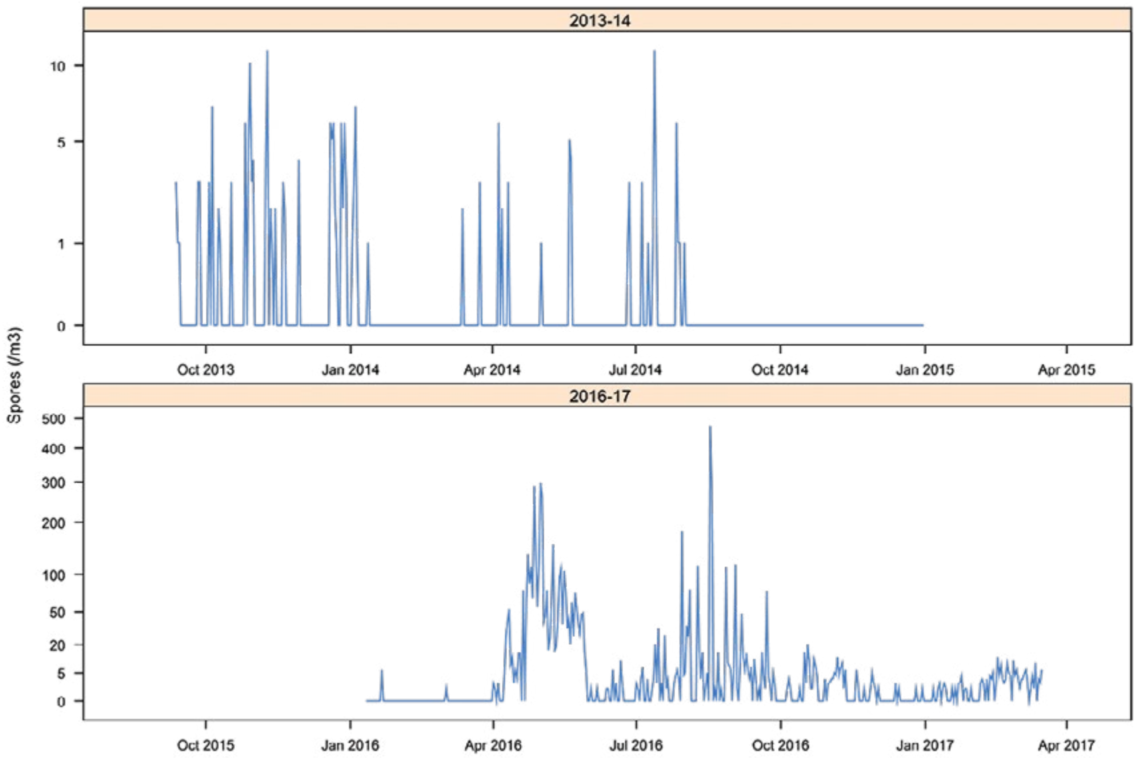

Figure 5. Daily blueberry rust airborne spore count from 2013–14 and 2016–17 on the NSW north coast. Note that a square root scale is used on the y-axis, and the y-limits for each period are different.

Symptoms

Although rust symptoms are most obvious on leaves when red-brown lesions are visible on the upper surface, and yellow pustules can be seen on the corresponding lower surface (Figure 6), the infection takes place much earlier.

Figure 6. Later stage symptoms of blueberry rust are seen as brown lesions on the upper leaf surface (left) with yellow pustules on the corresponding underside of the leaf (right).

Leaves

Blueberry rust first appears as small pale-bright yellow lesions on the upper surface of infected leaves (Figure 7). On the underside of the leaf, the fungus erupts through the surface and small pustules containing spores form (Figure 8).

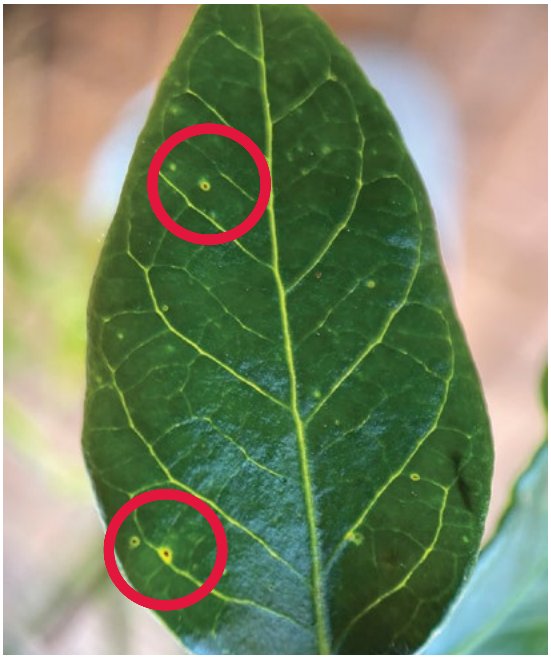

Figure 7. Rust initially appears as small pale-bright yellow lesions on the upper surface of infected leaves.

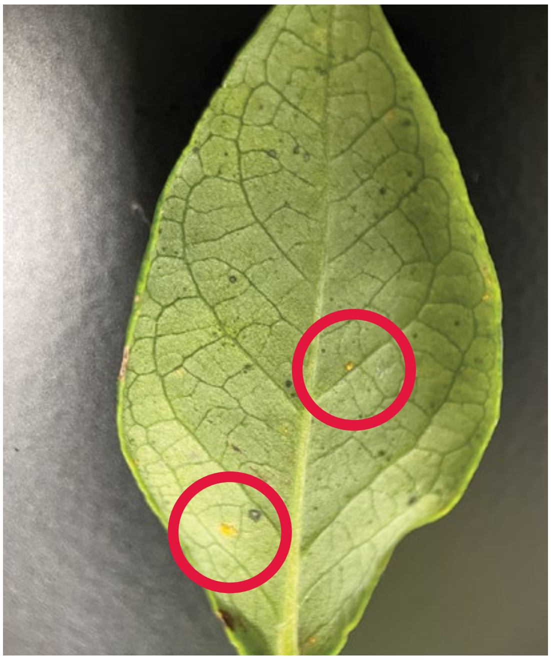

Figure 8. On the underside of the leaf, the fungus erupts through the surface and small pustules containing spores form.

As the disease progresses, the lesions become red to brown (Figure 9) and can increase in size, then merge with severe disease. The yellow spores on the underside of a leaf (Figure 10) are powdery when touched, and when there are many, they can be seen floating with air currents or wind. The infected tissue within the lesion becomes darker and surrounding tissue turns yellow as it dies, reducing the photosynthetic capacity (Figure 11). When disease pressure is high, bushes can be defoliated.

Figure 9. Dark reddish-brown spots on the upper leaf surface. Rust is well established.

Figure 10. Yellow-orange pustules on the underside of the leaf area are a source of inoculum for new infections.

Figure 11. Later stages of blueberry rust appear as dark spots merging, and the leaf surrounding the lesion is yellowing.

Fruit

Lesions develop on green (Figure 12) and ripe fruit (Figure 13) when disease pressure is high. Rust lesions can reduce the marketability of ripe berries. It is likely that infection takes place during flowering. Fungal DNA corresponding to *P. minimum* has been detected in flowers and ripening asymptomatic fruit. The infection process needs to be confirmed microscopically.

Figure 12. Blueberry rust symptoms on green fruit. It appears as purplish sunken lesions around the calyx, which typically has yellow spores.

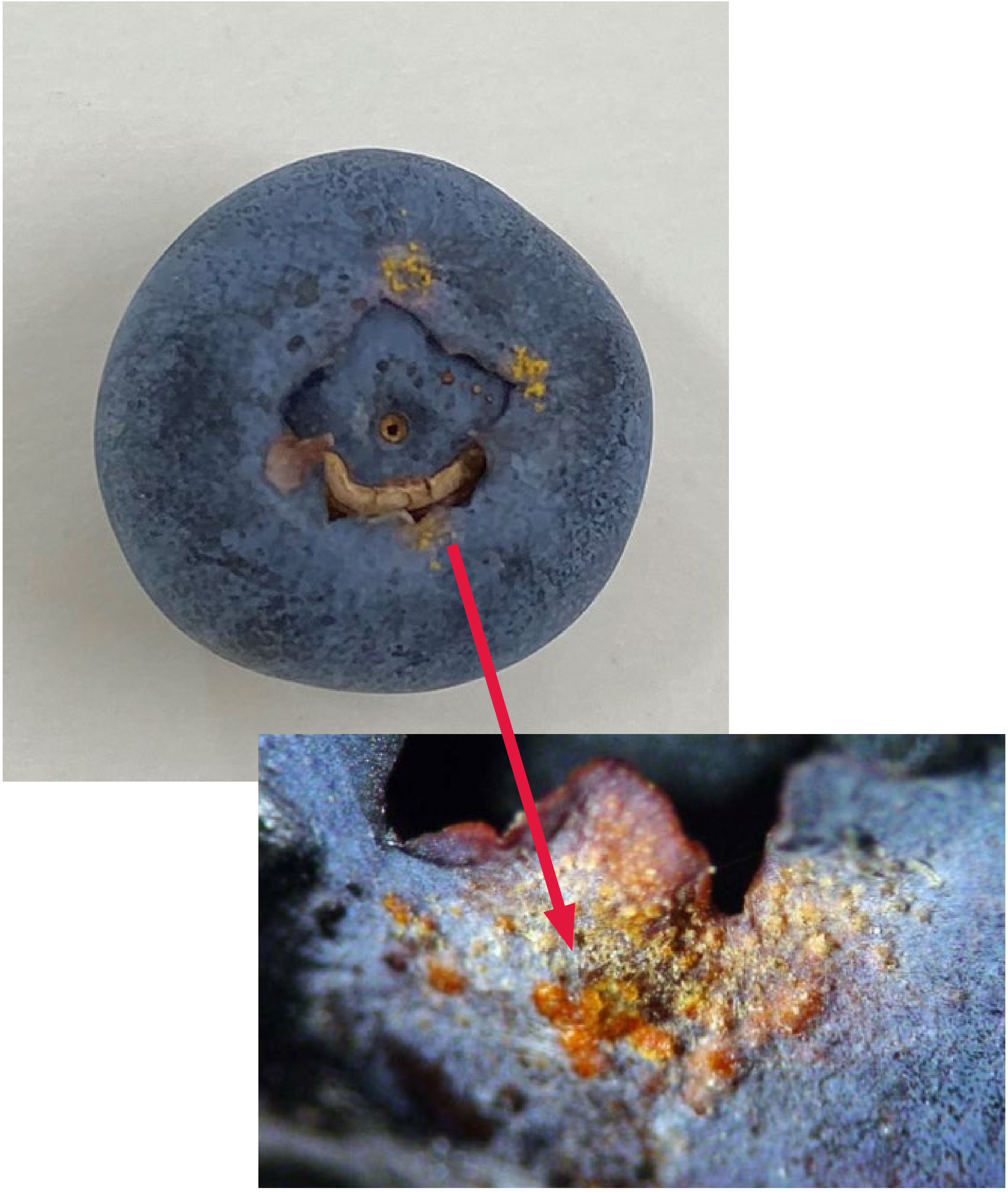

Figure 13. Blueberry rust symptoms on ripe fruit appear as yellow pustules around the calyx.

Diagnosis

Early diagnosis is the key to effective management. It allows the disease to be treated early and minimises the potential for inoculum build-up. The first symptoms of blueberry rust are small pale-yellow spots that develop on the upper leaf surface (Figure 7). To confirm the symptoms are due to blueberry rust, turn the leaf over and look for yellow spores. Powdery yellow pustules on the corresponding lower surface are characteristic of blueberry rust (Figure 8).

Blueberry rust can be confused with...

1. Early symptoms of rust can appear similar to oedema (Figure 14), which appears as small brown spots on the underside of the leaf. Oedemas are caused by water imbalance in the plant and are not caused by a pathogen.
2. Herbicide damage also results in brown lesions developing on the upper and lower leaf surfaces (Figure 15). These have a burnt-like appearance and do not have yellow pustules on the underside.
3. *Septoria albopunctata*, the cause of septoria leaf spot, causes circular lesions with red to black margins and grey centres on the upper leaf surface. Tiny black fruiting bodies might be seen in the centre of the grey section of the lesion if the infection is old (Figure 16). No yellow pustules occur on the underside of the leaf. Septoria is favoured by moist conditions.

Figure 14. Oedemas are visible as small brown spots on the underside of the leaf.

Figure 15. Herbicide damage can cause circular brown lesions on the upper and lower surface of leaves.

Figure 16. Septoria leaf spot appears as red lesions on the upper leaf surface. There are no yellow pustules on the underside, unlike rust infections.

Favourable conditions

Infection

Rainfall or moisture for leaf wetness and warm temperatures are required for infection. *P. minimum* spores germinate at temperatures between 5 and 30 °C, but optimum growth occurs between 15 and 25 °C. At these temperatures, relative humidity of 100% for at least 2 hours favours urediniospore germination. Infection requires high humidity, so germination and infection are less likely when relative humidity is low, for example when foliage dries quickly, even if temperatures are optimal (Pfister et al. 2004).

Incubation period

For the fungus to colonise leaf tissue after germination, blueberry rust requires at least 7 hours of leaf wetness at 24 °C to cause infection.

Managing the disease

Biosecurity

Put in place biosecurity best practice actions to prevent entry, establishment and spread of blueberry rust on your property.

- Rust spores can spread long distances by wind, on machinery, vehicles, tools, clothing (Figure 17), hats and footwear. Remember that if you walk through an infected crop, follow biosecurity protocols and thoroughly clean your boots, hands and clothing before entering another paddock or travelling, as rust spores can be unknowingly transferred via people.
- Check that visitors, including agronomists, follow biosecurity measures. Ask all visitors to leave their vehicle at the gate (Figure 18) and only travel on your property in your vehicle.

Figure 17. Orange dots on a black jumper are blueberry rust spores. Spores can easily spread via clothing, hats and footwear. Photo: Jay Anderson, SCU.

Figure 18. Biosecurity signs should be located on farm gates with a contact number so that you are aware of who is entering your property.

- Monitor plants regularly and after crop inspection, clean any material off boots with a brush. Preparing a footbath with bleach (10% household bleach, 90% water) and spray bottles with a methylated spirits mixture (95% methylated spirits, 5% water) to use for disinfecting footwear, clothes and hands are good biosecurity practices and should be carried out where possible.
- Source plant material of known high health status from reputable suppliers. Inspect nursery plants on arrival and store them separately from planted blocks. Monitor plants regularly before planting; it might be worth removing affected leaves and applying a fungicide spray before planting if blueberry rust is detected.
- Keep records.

Cultural practices

Cultural practices should be used to minimise conditions favourable for infection and the spread of blueberry rust, as well as to improve spray deposits on foliage. These practices include:

- Orientating rows in the direction of prevailing winds or northern facing slopes (where possible) to encourage airflow, and using appropriate planting densities to help minimise crowded canopies.
- Choosing blueberry cultivars with resistance to blueberry rust and planting those in high pressure areas.
- Pruning to open the canopy will promote ventilation and reduce the length of time that leaves remain wet and conditions favourable for rust infection. Opening the canopy can also improve contact and penetration of fungicides.
- Preventing water from pooling in the orchard (Figure 19) as this leads to high humidity, which can encourage blueberry rust infection. Ensure that wet and boggy areas are eliminated via better drainage.
- Using water and fertiliser inputs carefully, especially nitrogen, to minimise the growth of large dense canopies.

Figure 19. Pooling water can cause high humidity in an orchard, encouraging blueberry rust infection. Eliminate pooling where possible.

Fungicide options

Fungicides should be regarded as one component of an integrated approach to disease management. They protect a potential yield that might be realised without disease. Securing effective disease control from fungicide applications depends on prevailing environmental conditions, disease pressure and the effectiveness of the fungicide to control that disease. Understanding the pathogen, environmental conditions and host susceptibility is essential to establishing a targeted and effective spray program.

Optimal coverage

Adjust spray water volume to match the canopy size

Chemical application rate depends on the spray water volume (when using the per 100 L water rate), and spray water volume depends on crop canopy volume. An industry standard for spray water volumes in blueberries is shown in Figure 20. If spray water volumes are not matched to crop canopy volumes (i.e. less water than industry standard), chemical application rates should be adjusted (i.e. using a concentration factor) to achieve the same dose per plant. Using these water volumes and the per 100 L label rate will achieve the most desirable amount of chemical per leaf area. Dilute spray volume is required to calculate the correct amount of chemical to be applied to cover the canopy. Water-sensitive paper should be used to verify these volumes are providing adequate coverage.

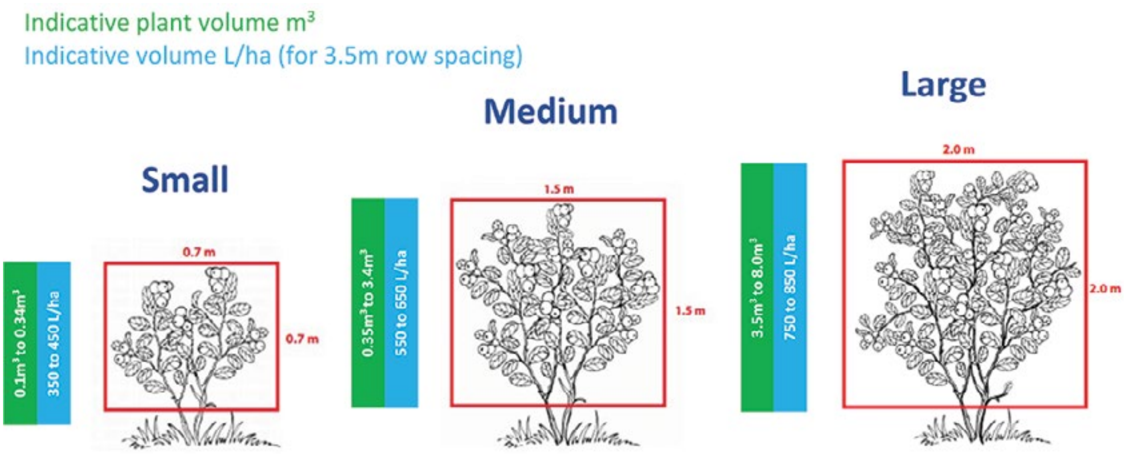

Figure 20. Industry standards for water volumes when spraying in blueberries.

Direct the sprayer output towards the target canopy

The main risk in spraying is failing to hit the target. To assess the spray output, park the sprayer in a block to be treated. Look at which nozzles should be turned on and what proportion of the output is directed to the different bush zones (Figure 21).

Figure 21. Assessing sprayer output is directed towards the canopy.

Adjust nozzles as required for better coverage and use water-sensitive paper to help assess this. To test the coverage, place 6 pieces of water-sensitive paper per plant, locating them on the top, middle and bottom of the bush, and the underside and top of the leaf surface for multiple plants along a row. Generally, 85 fine-medium-sized droplets per square centimetre (/cm^2), with about 15% total surface coverage, should be adequate for most foliar applications (Figure 22). An observer should monitor leaf movement to ensure sprayer-generated air is displacing the air within the canopy.

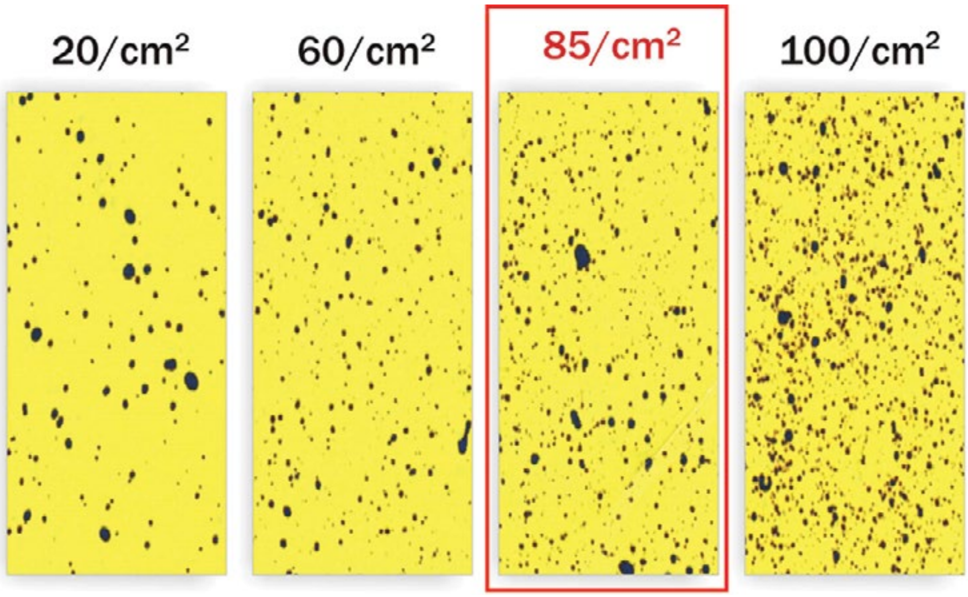

Figure 22. Water-sensitive paper can be used to test spray coverage, and 85 droplets per square centimetre provides good coverage. Photo: Jason Deveau, Sprayers 101.

Fungicides

Table 1 lists the fungicides permitted to control blueberry rust in Australia. Fungicides should be applied as close as possible before impending infection. Some evidence suggests that application just after rain is more effective, i.e. within the germination times of the fungus (Friskop et al. 2015; Zambolim 2016).

Table 1. Permitted products for blueberry rust in Australia. Always read and follow permit and label directions.

Chemical	Permit	Application rate	Withholding period	Permit expiry date
Azoxystrobin	PER89953	250 g/L product: 75–100 mL/100 L	1 day	31.10.2024
Boscalid + pyraclostrobin	PER82986	252 g/kg boscalid and 128 g/kg pyralcostobin: 1.25–1.5 kg/ha or 125–150 g/100 L	3 days	31.08.2024
Chlorothalonil	PER91300	500 g/L product: 144 mL/100 L water 720 g/L product: 100 mL/100 L water	28 days	30.09.2026
Copper present as copper hydroxide or cupric hydroxide	PER84176	500 g/kg product: 1.2 kg/ha or 105 g/100 L 400 g/kg product: 1.5 kg/ha or 130 g/100 L 375 g/kg product: 1.55 kg/ha or 140 g/100 L 350 g/kg product: 1.65 kg/ha or 150g/100 L 350 g/L product: 1.7 L/ha or 155 mL/100 L	1 day	31.12.2025
Dithianon	PER82601	700 g/kg product: 50 g/100 L	21 days	31.12.2026
Mancozeb	PER13958	750 g/kg product: 200 g/100 L or 2 kg/ha	7 days	31.08.2025
Polyoxin D Zinc Salt	PER92997	22g or 40 g/100L or 220g or 400 g/ha	Not required if used as directed	31.03.2025
Propiconazole	PER14740	250 g/L product: 32 mL/100 L or 320 mL/ha 500 g/L product: 16 mL/100 L or 160 mL/ha	3 days	30.06.2024

Key points about blueberry rust

Blueberry rust is a disease caused by *Pucciniastrum minimum*, a fungus that mainly infects leaves, causing reduced plant vigour and fruit set. When fruit is infected, marketability can be affected.

Pucciniastrum minimum survives primarily on and in infected leaves that remain on the plant after pruning. The fungus thrives in warm, wet conditions, especially when there are extended periods of leaf wetness (such as dewy conditions) and susceptible host tissue. In the evergreen system where leaves are continuously present, they can be infected with *P. minimum* throughout the year, but this can be difficult to detect. When conditions become conducive (warm and moist), the fungus is stimulated to form pustules and sporulate to reinfect.

Following infection, the fungus colonises the leaf and yellow pustules begin to appear after about 10 days at 23 °C. Thereafter, the small yellow lesions appear on the upper surface of the leaf where the infection has been. As the disease progresses, the lesions become red to brown and can increase in size, merging when disease is severe. The yellow spores on the underside of a leaf are powdery when touched, and when there are many, they can be seen floating with air currents or wind. The infected tissue within the lesion becomes darker and surrounding tissue yellows as it dies, reducing the photosynthetic capacity of the leaf. When disease pressure is high, defoliation can occur.

Managing blueberry rust requires an integrated approach involving:

- scouting blueberry plants to detect infections early so the disease can be treated and the potential for inoculum build-up is minimised
- monitoring weather conditions to identify when they are conducive to the infection and disease symptom development
- cultural measures including
  - actively implementing biosecurity practices
  - using appropriate cultivars and planting densities
  - pruning to enable airflow through the canopy
  - preventing water from pooling in the orchard
  - using water and fertiliser inputs carefully, especially nitrogen, to minimise growth in large dense canopies
- targeted application of fungicidal sprays
- spraying with the appropriate water volume, the sprayer is calibrated and the nozzles are directed to the canopy.

Blueberry rust management checklist

Biosecurity risk assessment	Yes	No	Unsure
Do you source clean planting material?			
Do you visually inspect your plants when they arrive from the nursery and remove affected leaves or badly affected plants?			
Do you ensure all visitors, contractors and tradespeople implement hygiene protocols and limit their movement on your property?			
Do you work from your cleanest blocks to your dirtiest blocks?			
Environment risk assessment			
Where possible, are your rows orientated in the direction of prevailing winds or northern facing slopes to encourage airflow?			
Do you ensure windbreak trees or tree lines do not shade your plants?			
Do you manage boggy spots where water pools leading to high humidity by ripping or drainage?			
Plant risk assessment			
Do you understand which blueberry cultivars are more resistant to blueberry rust and plant those in high pressure areas?			
Do you monitor your plants regularly for signs of blueberry rust?			
Do you remove and dispose of prunings from the field?			
Do you maintain an open canopy to increase air movement and reduce infection?			
Pathogen risk assessment			
Do you understand the different conditions in which blueberry rust thrives?			
Do you understand where and when blueberry rust hotspots occur in your orchard?			
Do you understand the difference between protective and systemic fungicides?			
Do you understand what fungicides are at most risk of becoming resistant and therefore be less effective?			
Is your spray water volume consistent with industry standard?			
Do you check your spray coverage regularly to ensure your sprayer is targeting the crop appropriately?			
Score			

Glossary

Aecia	a life stage of rust fungi
Asymptomatic	not showing symptoms
Biotrophic	feeds on living plant tissues
Ericaceae	a family of flowering plants
Heteroecious	passes through different life cycle stages on alternate and often unrelated hosts
Inoculum	a substance used for inoculation
Propagule	a vegetative structure that can become detached from a plant and give rise to a new plant e.g. a bud, sucker or spore
Pucciniastrum minimum	the pathogen that causes blueberry rust
Septoria albopunctata	the fungus that causes Septoria leaf spot
Sporulation	forming of spores
Teliospores	the thick-walled resting spore of some fungi
Thekopsora minima	former name for Pucciniastrum minimum
Urediniospores	any of the brownish spores that are produced in each uredium of the rust fungi
Vaccinium spp.	a plant genus to which blueberry belongs

References

Friskop AJ, Gulya TJ, Halley SA, Schatz BG, Schaefer JP, Jordahl JG, Meyer SM, Mesek KW, Hendrikson P and Markell SG (2015) Effect of fungicide and timing of application on management of sunflower rust. *Plant Disease* 99, 1210–1215, https://pubmed.ncbi.nlm.nih.gov/30695927/

Pfister SE, Halik S and Bergdahl DR (2004) Effect of temperature on *Thekopsora minima* urediniospores and uredinia. *Plant Disease*, 88(4): 359–362. DOI: 10.1094/PDIS.2004.88.4.359

Zambolim L (2016) Current status and management of coffee leaf rust in Brazil. *Tropical Plant Pathology* 41, 1–8, https://link.springer.com/article/10.1007/s40858-016-0065-9

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Hort Innovation Strategic levy investment | BLUEBERRY FUND
Hort Innovation Strategic levy investment | RASPBERRY AND BLACKBERRY FUND
Hort Innovation Strategic levy investment | STRAWBERRY FUND

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