Managing Rust of Almonds

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Introduction

Almond rust is a wet weather disease. It grows best in warm humid conditions especially when there are extended periods of leaf wetness. Defence against rust is a major factor triggering orchard sprays in spring and summer. In recent years there has been good progress toward improving the clean green image within the industry. This, linked with more sustainable orchard practices, gives focus to ways in which specific information on the risk of disease events can guide the need to apply fungicides against rust. A "Three-step Rust Reckoner" provides a guide to the conditions that favour rust infection and indicates when sprays are needed.

The Disease

Rust is most obvious on leaves where rusty-brown powdery pustules develop on the undersides of small yellow leaf spots. The disease is sporadic in most regions of Australia because it is driven by warmth and moisture, and only at irregular times and seasons when the conditions are sufficiently warm and wet enough for long enough.

Crops Infected

Commonly called ‘prune rust’, the disease in almonds is more correctly known as ‘almond rust’ or more simply, ‘rust’. This is because the fungus that causes the disease (Tranzschelia discolor f. sp. dulcis) infects almonds but not plums. Similarly, the form of the fungus that infects plums or prunes will not ‘cross-infect’ almonds. However, it is interesting to note that the two forms (sub-species) of the rust fungus spread in similar conditions.

Symptoms

On leaves

Rust first appears as many small (1-2 mm) angular, pale-bright yellow lesions (spots) on the upper surfaces of infected leaves (Figures 1a, b & 2a). These spots are usually limited in size and shape by the finest veinlets and are often grouped in small irregular clusters of 3 or more spots. With age, the spots often turn a golden yellow.

After the leaf spots appear, the lower surface of the spot breaks open forming a powdery pustule through which the orange-brown rust spores of the rust fungus (uredospores) erupt. In favourable conditions, each pustule produces yellow-orange to rusty brown, rounded tufts of these spores (Figures 1c & 2b). If touched, the spore masses readily leave a rusty brown deposit on your finger. This is diagnostic for rust disease.

As the leaf spots age, they turn golden yellow and then brown as the affected tissue within the spot dies. As symptoms progress on affected leaves, the tissue between the leaf spots turns yellow more quickly than the initial infection sites (Figures 3a, b). This is because the disease disrupts normal leaf function and causes the green chlorophyll activity to decline so that, eventually, a severely diseased leaf may appear yellow with scattered small green spots across the surface at each of the initial rust infection sites. This is characteristic of rust on severely diseased foliage late in the season.

Old pustules particularly in the autumn may turn black when a different type of spore, the winter or black rust spores (teleutospores) are produced. These appear to play no role in almond rust in Australia.
On shoots

The disease only affects shoots when disease severity on leaves is high. Rust on shoots appears as dark brown spots from which the characteristic rusty-brown pustules emerge in warm humid weather.

Diagnosis

Severely affected leaves fall from diseased sectors of trees. If infection is severe across trees, patches of defoliated trees will appear in the orchard.

Do not confuse rust spots with similar symptoms caused by other factors. Some symptoms will show yellow spots that also have a tiny dark centre. These may be the result of herbicide damage, for example, caused by the knock-down herbicide, paraquat. The fungal disease shot hole also causes similar spots but these have tan centres and develop a reddish brown margin (halo). Sometimes, tiny dark brown spores of the fungus (sporodochia) develop in the centre of these spots which later die and fall out, leaving a 'shot holed' appearance. Distinguish herbicide damage from shot hole by the spots that will sometimes cross the finest veinlets. Wherever a droplet of herbicide makes contact with the leaf it burns a little spot, even across the veinlets. In contrast, the shot hole fungus causes spots usually delimited by the finest veinlets. Herbicide damage will appear a few days after application whereas like rust disease, the spots from shot hole will appear more than 10 days after favourable wet conditions. But, only rust produces the rusty brown spore tufts in pustules on the undersides of the leaf spots.

Varietal Susceptibility

Most of the commonly grown almond varieties are susceptible to rust. A few varieties, when infected, show limited symptoms on upper leaf surfaces displaying only a few leaf spots before the rust pustules appear on the under surface of leaves. To the contrary, some varieties produce the yellow leaf spots but few pustules on the under surface.

Disease Cycle

Overwintering

In Australia, rust begins from inoculum (urediniospores) on leaves infected last season but remaining attached over-winter in trees (Figures 4, 5). The disease is rarely triggered by inoculum from fallen leaves.

First infection

Rust is a 'green disease' meaning that it only infects green tissue. As a result, on unsprayed foliage, infection can begin if favourable conditions, particularly surface moisture on leaves, occur anytime from when leaves first emerge (Figure 4 a-d).

Figures 3: Progression in chlorosis (yellowing) of leaves severely affected by rust. The disease disrupts chlorophyll function (which relies on green tissue to produce food for the developing crop). Affected leaves turn yellow (3a) with scattered green speckling (3b) indicating where the rust infection had occurred. Severely diseased leaves fall prematurely – this can defoliate trees in patches or across an orchard.

Figures 2: To monitor for almond rust, look for the typical yellow lesions (spots) of the rust fungus on upper leaf surface of almonds (2a). Confirm their identity by turning the leaf over to find the characteristic raised, rusty pustules on undersides (2b).

Figure 2a

Figure 2b

Figure 3a

Figure 3b
Spores from leaves infected last season spread in the wind and rain to infect nearby foliage.

**Incubation**

Once infection has occurred, a period of incubation follows. This is the time between infection and when symptoms first appear. It will last several days (see later) after which small yellow spots will appear wherever infection occurred in the foliage.

**Spread**

The rust pustules beneath the spots produce more spores and if fungicide sprays have not adequately protected the foliage, the disease will spread. A second incubation period will follow after which many more spots will appear.

The disease cycle continues as long as favourable weather occurs and unsprayed foliage is available to infect. The youngest foliage is very susceptible. As leaves mature, they gain a level of age-related (ontogenic) resistance though they never become fully resistant.

Usually, only a few spots (with pustules beneath) will show after the first infection event. Perhaps initially 5-50 pustules/leaf will develop in a cluster of foliage 20-50cm in diameter around the initial source of inoculum. These spots may pass unnoticed. Subsequent infections, especially in early-mid season, can produce many hundreds of leaf spots, often from 15-500 pustules/leaf within a zone 0.5–1.5mm in diameter. In this way, if favourable conditions persist and adequate controls are not applied, rust spore numbers initially build-up slowly but then may explode, infecting several branches in one sector of a tree and/or often spreading rapidly across an unsprayed block of a susceptible variety in the orchard.

**Crop Loss**

In wet seasons, a series of favourable weather events can trigger a number of infection periods that will lead to severe disease in unprotected trees. This can defoliate trees by mid-late season. As a result, rust can cause significant crop loss this season and reduce tree vigour and bud viability in the next.

**Favourable Conditions**

Rust spreads in warm humid conditions especially when the foliage is more susceptible in early spring and summer. The spores of the rust fungus are very durable and survive long periods of dryness but they need free-water and adequate temperature to germinate, grow and cause infection.

**Infection**

The main factors required for infection are rainfall (or precipitation) to wet the foliage for sufficient length of time while there is adequate warmth for the fungus to develop and grow.

Spores of the rust fungus germinate at temperatures from 5 to 30°C but grow best at optimal temperatures of 15 to 24°C.

**Incubation period**

Temperature is the main factor that governs the speed with which the yellow spots appear after infection, ie the length of the incubation period. Preliminary evidence suggests that in cooler conditions between 10 to 15°C, the incubation period is about 20 to 22 days whereas in warmer conditions around 20 to 25°C, it appears to be nearer 13-19 days.

**Spread**

The main factors that control the rate and extent of the spread of rust is the speed and severity of the epidemic, are the initial number of spores (overwintering inoculum), the timing of rain events and the relationship between temperature and length of leaf wetness in the prevailing conditions.

**Managing Disease**

Spores of the rust fungus cannot infect unless there is water on the leaf or shoot surface. The cultivation of almonds in semi-arid environments, as occurs in most almond regions of Australia, provides good basis for minimum risk from rust. Spray schedules for other foliage diseases of almond, including shot hole and blossom blight, may contribute to suppression of rust epidemics in the orchard.
For a given climatic region and for a specific variety cultivated, the main direct means of controlling rust involve reducing inoculum carry-over from one season to the next, and the use of well-designed spray programs.

**Over-wintering inoculum**

Good disease control in the previous season results in fewer infected leaves hanging on the tree over winter (Figure 5) and, as a result, less risk of disease if favourable weather prevails next spring. In autumn, consider cultural practices that lead to complete leaf fall (Figure 6).

**The Three T’s of Good Spray Practice**

**Type**

**Event based.** Prior to spraying, select the type of fungicide best suited to the timing of disease events:

1. **Pre-infection sprays.** ‘Protectant’ or surface acting fungicides protect the foliage from infection. Because these fungicides do not move to cover new leaf and shoot growth, apply these as close as possible prior to an infection event.

   Examples of pre-infection fungicides that prevent almond rust infection include Strobilurin fungicides, chlorothalonil and mancozeb.

2. **Post-infection sprays.** ‘Curative’ fungicides are better known as ‘trans laminar’ products. Absorbed by the sprayed foliage, they move within and across leaves and kill or at least, inhibit the rust fungus developing inside infected foliage. Because these products also have activity in protecting against rust infection, it is best to apply these fungicides as soon as possible before infection, or as close possible after an infection event.

   Being absorbed in sprayed tissue, these fungicides are quickly rain-fast. Like the pre-infection fungicides though, these products do not move in adequate concentrations to control the fungus in unsprayed foliage.

   Examples of post-infection fungicides that inhibit existing rust infections include the DMI fungicides.

**Timing**

**Seasonal.** It is critical to ensure good disease control for rust in early to mid-season when the foliage is most susceptible and when the leaves are most needed as food factories to supply nutrients to the developing fruit crop.

**Monitoring Infection Events.** Optimise
Table 1. Use the ‘Three-step’ Rust Reckoner as a guide to the conditions required for infection by almond rust in your orchard.

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<th>Temperature (Average °C)</th>
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Comment

Generally, across Australian almond orchards, there have been relatively few infection events and regular schedules of fungicide spraying has been effective in protecting the foliage from rust. However, there is scope to use the Three T’s to design better spray schedules for cleaner, greener production of almonds in orchards with optimised use of fungicides and pesticides. The world trend to a more prescriptive trace-back system in marketing fruit products will allow consumers to determine the reason why and when sprayed chemicals were used.

Use of more targeted approach to spraying is both possible and likely to be useful in marketing strategies for Australian

Further Reading

Presentations/publications on almond rust:


Magarey, PA and Wicks, T.J. (2008). Presentation of project objectives and outcomes was made to levy payers at their meeting at the ‘We’re Blossoming’, Australian Almond Industry 2008 Conference, Novotel Barossa Valley Resort, 29 - 31 October 2008, Rowland Flat, South Australia.


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