Identification & Management of Field Crop Diseases in Victoria

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NSW GOVERNMENT Department of Primary Industries

THE UNIVERSITY OF MELBOURNE

Identification & Management of Field Crop Diseases in Victoria

October 2022

Editor

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Printed by: Finsbury Green, Web www.finsbury.com.au

Designed by: Bonnie Severin Designs bonnieseverin.com

Acknowledgements

Since this book was first published in 2009 a great number of people have contributed time and information. Everything from writing book chapters through to the editing the book. In alphabetical order these are:

- Wendy Bedgegood
- Dr Trevor Bretag
- Dr Vicki Elliot
- Dr Angela Freeman
- Frank Henry
- Dr Pragya Kant
- Helen Richardson
- Dr Matthew Rodda
- Dr Merrin Spackmann
- Dr Jason Brand
- Sarah Brown

We would particularly like to thank our external reviewers, Dr Kurt Lindbeck and Dr Fran Lopez-Ruiz, for contributions to the 2018 and 2022 editions.

ISBN: 978-1-74217-752-6 (print)

Accessibility

If you would like to receive this publication in an alternative format, please telephone the Customer Service Centre 136 186, email customer.service@depi.vic.gov.au (or contact Department of Jobs, Precincts and Regions, 110 Natimuk Road, Horsham, Victoria 3400), or via the National Relay Service on 133 677 www.relayservice.com.au.

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Authors: Luise Fanning (Agriculture Victoria) and Dr Grant Hollaway (Agriculture Victoria)

INTRODUCTION TO CROP DISEASES

Crop diseases are as old as agriculture itself and have often caused hardship for people across the world. Early literature refers to the Romans sacrificing a red dog every year to appease the rust god Rubigus, hoping to ensure a rust-free harvest. During 1845-52, potato blight in Ireland caused the Great Famine and was estimated to have resulted in one million deaths and caused mass emigration. More recently the Stem rust strain Ug99 has caused international concern as it has spread through Africa and beyond.

On a more local scale, Ascochyta blight severely impacted Wimmera chickpea crops in the late 1990s and brought hardship to many farmers. With the development of good disease management strategies and cultivars with improved resistance the chickpea industry has since recovered.

Due to their ever-changing nature diseases remain a constraint to field crop production, but fortunately modern agriculture is able to minimise the impact of diseases on production through the use of improved knowledge and the implementation of integrated control strategies.

Within this manual the general principles of plant pathology and disease identification and control are addressed for the important field crops grown in Victoria.

What is a Disease?

Technically a disease can be defined as any deviation from what may be considered 'healthy'. These broad definitions include diseases caused by environmental or physiological factors as well as living organisms, hence diseases are generally split into two categories; biotic (living) and abiotic (non-living) threats. This book focuses on biotic diseases which are caused by living organisms. Abiotic diseases are caused by non-living factors (e.g. nutrition and moisture stress) and are commonly referred to as disorders and will not be a focus of this book.

In terms of biotic crop diseases, a plant becomes diseased when it is successfully attacked by a living organism (i.e. a pathogen) and symptoms appear. For this to occur the pathogen must overcome any resistance mechanisms a plant has and compromise it at a cellular level resulting in development of disease symptoms. These symptoms allow for identification and management of the disease.

Diseases can affect many different parts of the plant and this influences the symptoms that appear. Diseases that affect roots and stem bases cause damage by interfering with water and mineral absorption from the soil. This can result in wilting or symptoms of nutrient deficiency. Diseases that affect leaves can cause leaf death. This directly affect a plants ability to produce sugars via photosynthesis. Other diseases (e.g. systemic viral diseases) impair translocation of sugars, produced during photosynthesis, to the grain which can produce shriveled grain, and diseases such as bunts and smut can destroy developing grains. Not all symptoms are visual, diseased plants can have reduced grain protein as the diseases prevent the translocation of sugars in the plant.

Pathogen vs Disease

In plant pathology the terms pathogen and disease are used regularly, and it is important to understand the different meanings of these two terms. The pathogen is the organism that causes the disease. For example, the fungal pathogen '*Puccinnia striiformis*' causes the disease 'Stripe rust in wheat'. The disease is the effect of the pathogen on the plant or what we often see as symptoms. We can have a pathogen present, but not have disease develop (for example in a resistant variety, or if conditions are not suitable for disease development). However, we cannot have disease without the pathogen.

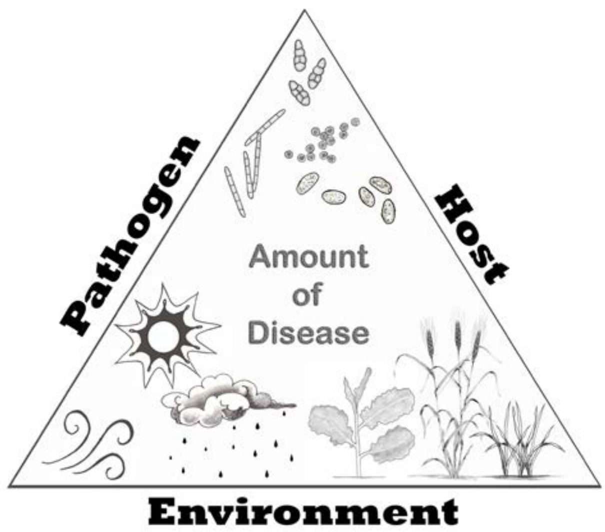


Figure 1.1. The disease triangle

Disease Development

The major factors affecting disease severity can be linked together in the Disease Triangle (Figure 1.1). Each side of the triangle represents one of three components: environment, host and pathogen. Each of these three components are required for disease to occur. For example, if you remove the susceptible host and grow a non-host species, you not will get disease.

The environment has a major influence on the infection process and often determines the incidence and severity of a disease.

If conditions are too dry or too cold the pathogen may not be able to successfully attack the plant. For example, for Stripe rust infection to occur there needs to be between 5-6 hours of leaf wetness (or high humidity) with a temperature range of 9-18°C. These requirements are different for other pathogens, but moisture is a relatively consistent requirement for initial infection to occur (Table 1.1).

While there are generally more disease problems in wet years, different seasonal conditions will suit different diseases and change the impact they will have on crop yields. For example, wet springs will favour the cereal root disease Take-all, while dry springs favour Crown rot expression. The term 'expression' is important as the crown rot fungus may infect plants every year, however, the expression of the whitehead disease symptom is what results in yield loss. This is why the environment is a critical component of disease development.

The chain of events that occurs during disease development is called the disease cycle. The incidence and severity of the majority of plant diseases vary on a distinct cyclic basis. Each cycle includes two alternating phases; the parasitic phase and the survival or over-summering phase.

Survival over summer (or from one crop to the next) is dependent on environmental conditions and the environmental requirements of the pathogen. Rhizoctonia and Take-all survive well during dry summers when there is little break down of plant residues or competition from other organisms in the soil. Rusts on the other hand survive only on living host plants and their survival is favoured by wet summers which support growth of volunteers (i.e. green bridge).

For a disease to establish the pathogen must first come into contact with the host plant. This disease inoculum is generated by previous infections and liberated into the environment; it may come from the same location or have travelled over great distances. Inoculum may be primary (resulting from infections in the previous season), or secondary (arising from infections in the same season).

Wind is the most important way in which fungal spores (e.g. rust spores) are disseminated over long distances. Rain splash is important for some fungal pathogens (e.g. Septoria) to spread, especially over short distances. Water also plays an important role for fungus like organisms pythium and phytophthora (oomycetes) allowing their free swimming spores move rapidly from host to host.

For other diseases (e.g. Rhizoctonia, Take-all, Crown rot) the inoculum comes from infected plant debris remaining in the soil.

Over the past few centuries humans have become one of the most effective ways in which crop diseases are spread. On a local scale this includes machinery, vehicles, and clothing but are not limited to these. This can be taken to a global scale where airplanes, ships and other transport have been instrumental in spreading many diseases.

Disease Epidemics

When referring to disease epidemics the disease triangle becomes a complex interaction between the pathogen, host plant, environment, and time. By incorporating time, disease spread and severity can be demonstrated. A change in environment over time can reduce the severity of the epidemic or increase the severity depending on the conditions. For example, an initial stripe rust infection may not result in an epidemic depending on the conditions following the infection. However, if conditions are conducive, no management is undertaken, and the host is susceptible then these are the conditions for an epidemic.

The distribution and genetic diversity of host populations are of great importance in determining the degree and rate of epidemic development.

As an example, if a whole district is planted to a wheat cultivar susceptible to Stripe rust (e.g. cv. Mace in eastern Australia) and Stripe rust become established there will be a large pool of spores to spread, thus increasing the risk of an epidemic.

The risk of a disease outbreak also increases if there is an over reliance on one resistance gene for disease control. This puts a very high selection pressure on the pathogen and mutations that have overcome that resistance gene can rapidly increase in the population.

Table 1.1. Conditions needed for development of rusts in wheat

CROP	DISEASE	PATHOGEN	TEMPERATURE °C		LEAF WETNESS[1] (HOURS)	LATENT PERIOD[2] (DAYS)	SPORE DISPERSAL	PRIMARY INOCULUM SOURCE
			RANGE	OPTIMAL				
Wheat	Leaf rust	*Puccinia triticina*	10-35	15-25	3	7-10	Wind	Volunteer wheat
	Stripe rust	*Puccinia striiformis*	0-23	10-15	3	20-86	Wind	Volunteer wheat
	Stem rust	*Puccinia graminis*	15-40	20-30	6-12	14	Wind	Volunteer wheat

(1) The longer the period of leaf wetness the greater the chance of successful infection.

(2) The latent period is the amount of time after infection before symptoms are present. It generally decreases as temperature increases within the optimal range.

Diagnostics Checklist

Plant diseases can be difficult to diagnose, but good diagnosis usually starts with gathering background information as well as the symptoms observed. For example, there may be some discolouration on wheat roots, but paddock history shows that root lesion nematode susceptible crops were grown. Also, knowing the susceptibility of the variety to important diseases, and herbicide history of the paddock can all help with diagnosis.

For diagnosis, it is helpful to know:

- sorts of disease expected at the particular time of year or under the prevalent weather
- common diseases of the host in question
- sorts of troubles peculiar to the area.

The following is an outline of some of the causes and characteristics of the more common diseases and disease-like symptoms seen in crops and things to consider during your diagnosis.

Symptoms of Common Diseases

When diagnosing symptoms, you'll need to investigate the:

- internal, as well as, the external parts of the plant; attempt to determine what part of plant was affected first
- history of symptoms
- leaves and stem(s) of affected plants
- flowers
- roots (dig up suspect plants, wash soil from roots and examine carefully – preferably in a tray of water).

Distribution of Affected Plants

The distribution of the affected plants within a paddock can often help point to whether symptoms are caused by a disease or some other factor. Take time to get a thorough overview of symptoms in the crop. Make a sketch or take a photograph.

Affected plants occurring in rows or lines could indicate:

- malfunction of equipment such as sowing depth or problems with fertiliser or herbicide application
- herbicide spray overlap
- infectious disease spread by contact and consistent with cultural operations
- a pathogen like cereal cyst nematode that can be dragged along the rows during cultivation.

Random individual affected plants may be caused by:

- seed-borne disease
- spores blown in from a great distance
- an insect that spreads the pathogen.

Affected plants that are more concentrated on the edges of the paddock, may be caused by:

- insect vectored disease
- spores or cysts blown in from adjacent paddocks
- pesticide drift from adjacent paddocks.

Affected plants occurring in patches could indicate:

- soil-borne disease such as Cereal cyst nematode or Rhizoctonia root rot
- soil type
- insects such as aphids, or virus spread by aphids.

Uniformly affected plants across the paddock, more likely to be caused by:

- herbicide damage
- nutrient deficiency or toxicity
- stubble-borne diseases.

While there are a number of diseases that affect each crop, most have key characteristics that can be used to help identify them in the field. The symptoms associated with common field crop disease in Victoria are discussed in the following chapters. These include diagnostic features, potential yield loss and key management strategies.

RESISTANCE RATINGS

Authors: Luise Fanning (Agriculture Victoria) and Dr Grant Hollaway (Agriculture Victoria)

INTRODUCTION

Genetic resistance in varieties provides cheap and effective disease management options which reduces reliance on fungicides and production risk for growers. In Australia, all field crop cultivars are independently rated by the Grains Development and Research Corporation (GRDC) through their National Variety Testing (NVT) program for their resistance/susceptibility to important diseases before commercial release.

Resistance ratings are updated annually and published in regional disease guides for cereals, pulses and oilseeds.

Understanding the resistance/susceptibility to diseases is important for growers when selecting cultivars and effectively planning their disease management strategies.

This chapter explains disease resistance ratings, how they are generated and how disease ratings can be used to inform disease management plans.

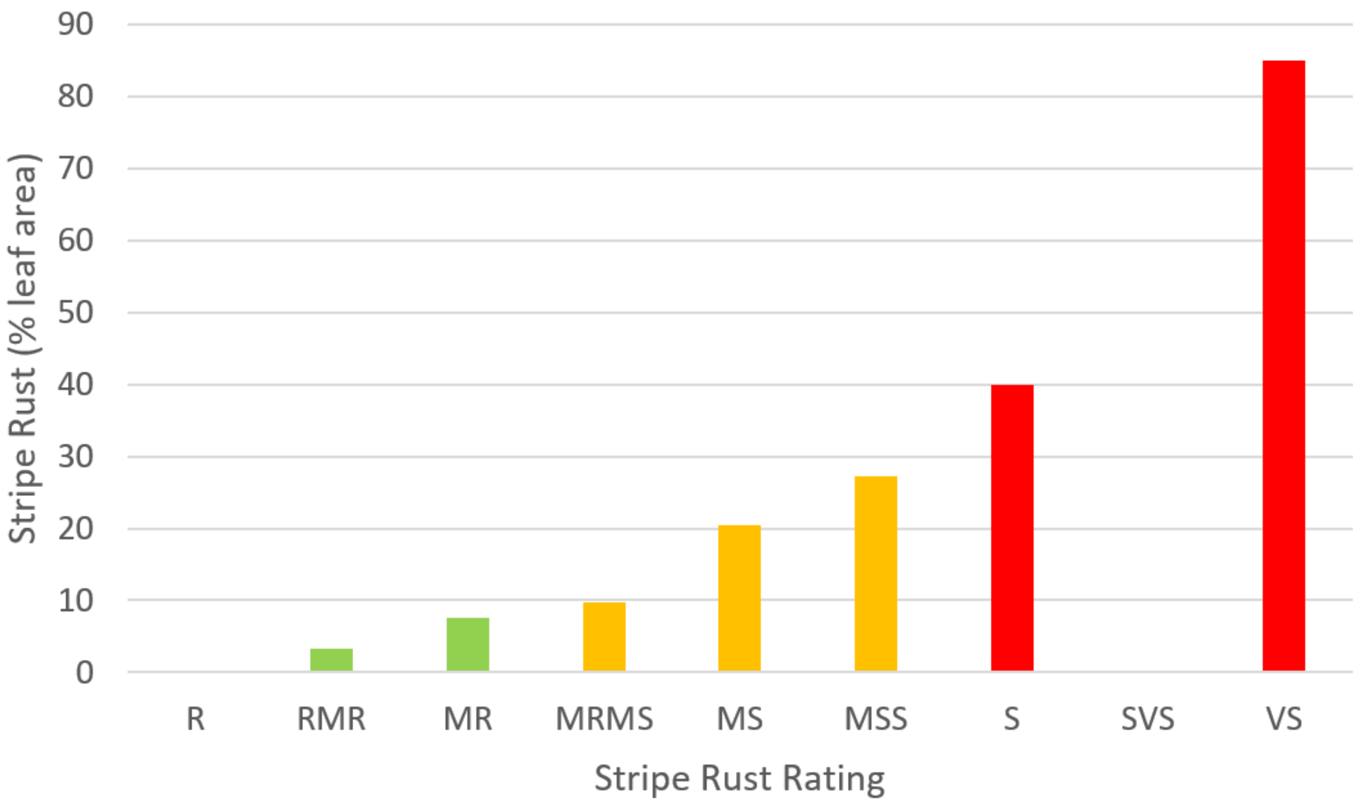
Figure 2.1. Wheat that is resistant (left) and very susceptible (right) to Stripe rust.

Disease ratings: What do they mean?

Disease ratings describe how much or little disease a variety is likely to endure during seasons conducive to disease development when the pathogen is present. Disease is unlikely to develop within crops when the season is not suitable for disease development or the pathogen is not present; hence even highly susceptible cultivars may be disease free in some seasons.

Field crop varieties are rated for their disease reaction using a nine-point scale ranging from Resistant (R) through to Very Susceptible (VS), as shown in Table 2.1. These ratings describe the level of genetic resistance present in a variety to each disease. A variety rated as Resistant will typically show no symptoms of disease, while those rated as Very Susceptible can suffer large damage when the disease is present (Figure 2.1). All ratings between these two extremes have some resistance that slows disease progression to different degrees. That is, even cultivars with a Susceptible (S) rating have some resistance when compared to cultivars with a Very Susceptible (VS) rating.

The relationship between disease rating and leaf area affected with Stripe rust is shown in Figure 2.2. This shows that as a variety's resistance rating decreases, the leaf area affected with Stripe rust increases. How much disease is present in any cultivar in any given season is influenced by the inoculum present and the seasonal conditions. Equally, the disease rating relates to the relative yield loss cultivars are likely to suffer in the presence of disease when conditions are conducive for yield loss (Figure 2.3).



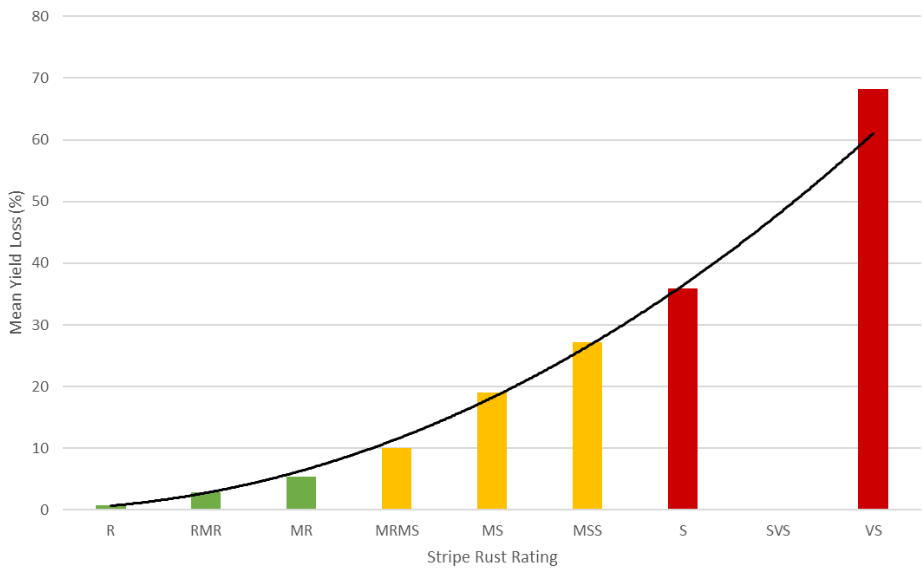


Figure 2.2. (Top): The relationship between resistance rating and percentage leaf area affected by Stripe rust.

Figure 2.3. (Right): Relationship between resistance rating and yield loss caused by Stripe rust using data collected from six locations across south eastern Australia during 2005 (yield data courtesy of AGT).

How are they developed

Disease ratings in Australia are developed by plant pathologists in a nationally co-ordinated program of both field and controlled environment testing. The work is funded by the GRDC through its NVT program with the work undertaken by specialist plant pathologists across Australia. Advanced breeding lines that are submitted to the NVT for yield evaluation and a large range of important commercial varieties are independently tested for a range of important diseases.

Within each experiment the test lines are exposed to a high disease pressure to enable assignment of a disease ratings.

The lines are then assessed for disease severity by an experienced research scientist. The disease severity data from a single experiment is then combined with data collected in different environments and seasons and then a disease resistance rating using the nine-point scale, from Resistant to Very Susceptible (Table 2.1) is then assigned. The ratings are developed in collaboration with multiple researchers and then published in regional disease guides for each state and on the NVT website (nvt.grdc.com.au).

Why can a variety have a different rating in different states?

Disease ratings reflect the strains of disease present in each region. Where a disease is known to have a similar virulence profile nationally (that is the same strain is across the country) then a nationally rating is applied. An example of this is Yellow leaf spot in wheat.

However, where different stains of a disease are known to occur in different regions then regional ratings are applied. For example, the wheat Stripe rust present in eastern Australia is different to that in Western Australia.

Therefore, Stripe rust wheat varieties are given an eastern and western rating (for example, the wheat cultivar Mace rated SVS in eastern Australia is rated as R in Western Australia). Not all cultivars will have a different Stripe rust rating in the east vs the west, as it depends on the different resistance genes in cultivars.

Ongoing monitoring of pathogen strains present nationally is important in informing the rating assigned to cultivars. An example of on-going monitoring is the work of the Australian Cereal Rust Control Program at The University of Sydney where the cereal rusts present nationally are monitored.

Why do ratings change?

Disease ratings do change over time. This can occur when a pathogen becomes more virulent (also known as resistance breakdown) making a previously resistant cultivar more susceptible.

This change can be due to mutation or sexual recombination within the pathogen population or introduction of a new more virulent strain from another region or another country. Since resistance ratings are known to change, it is also important to always consult a current disease guide.

Disease Ratings in Practice

Understanding and using ratings to support disease management decisions is an important part of an integrated disease management plan.

Using ratings in practice

Using Stripe rust and Yellow leaf spot as an example for wheat, we know that the wheat variety Mace is rated SVS for Stripe rust and MRMS for Yellow leaf spot. In contrast, Yitpi is rated MRMS for Stripe rust and SVS for Yellow leaf spot.

In practical terms this means that if planting wheat into a paddock where old wheat stubble is present it would be better to plant Mace in preference to Yitpi, due to the risk of Yellow leaf spot. However, given the high susceptibility of Mace to Stripe rust it is important to have a plan to manage this disease.

When disease resistance ratings are used in this way they can become part of the overall farm management plan, helping with crop rotations and chemical management plans.

Understanding ratings

It is important to know what ratings mean in terms of management within each crop. Cereals and pulses differ slightly in terms of disease management in resistant cultivars and it is important to know how this affects disease management. For a pulse crop, if there is severe disease pressure on a resistant cultivar a fungicide application may still be required to control the disease.

A resistant cereal crop on the other hand should be monitored for breakdown of resistance but is unlikely to need fungicides for disease control.

It is also important to note the pulse cultivars may be resistant to foliar Ascochyta blight but may not be resistant to Ascochyta pod infection. This means even resistant crops need to be monitored with a view to apply fungicide if there is infection during podding.

See table 2.1 for rating definitions.

Table 2.1. Ratings of cereal and pulse varietal resistance and what they mean. Current as of Sept 2022.

DISEASE RATING	SYMBOL	DESCRIPTION	
		CEREALS	PULSES
Resistant	R	Disease symptoms may be found at very low levels following close crop inspection. Generally, no management is required even in instances of high disease pressure. Monitor crops for breakdown in resistance.	The disease will not multiply or cause any damage on this variety. However, under severe disease pressure fungicide applications may be required.
Resistant – Moderately Resistant	RMR	Disease symptoms may be found at low levels following close crop inspection. Generally, no management decisions will be required. Monitor crops for breakdown in resistance.	
Moderately Resistant	MR	Disease symptoms may be observed, but generally no management decisions will be required. However, under severe disease pressure active management may be necessary. Monitor crops for disease.	The disease may be visible and will multiply slightly, but it will not cause significant loss. However, under severe disease pressure fungicide applications may be required.
Moderately Resistant – Moderately Susceptible	MRMS	Disease symptoms may be observed, but generally no management decisions will be required.	Preventative action may be economic in years with high disease pressure. Monitor crops.
Moderately Susceptible	MS	In seasons conducive to disease, symptoms will be detected during crop inspections. If the disease appears early in the season, then preventative action may be necessary. Crop losses of 15 per cent or more can occur in severe cases. Monitor crops.	The disease may cause losses up to 15 per cent or more in very severe cases.
Moderately Susceptible – Susceptible	MSS	In seasons conducive to disease, symptoms will be detected during crop inspections. When varieties drop below this minimum level of resistance there can be a build-up of disease. Still a useful level of resistance. Management decisions could be required to reduce disease. Monitor crops regularly.	
Susceptible	S	Disease symptoms will be easily found during crop inspections. Management decisions will be required to reduce disease. Expect yield loss in the range of 15-50 per cent without management. Monitor crops regularly.	The disease can be severe on this variety and losses of 15-50 per cent can occur.
Susceptible – Very Susceptible	SVS	Disease symptoms will be easily found during crop inspections. Crop loss can be greater than 50 per cent in the absence of management. It is not recommended to grow varieties with low resistance if the disease is common to the area. Monitor crops regularly.	
Very Susceptible	VS	Disease symptoms will be easily found during crop inspections. The use of this resistance level is not recommended if the disease is common in an area, as there can be total crop loss. Active management with fungicides is not generally considered economic.	This variety should not be grown in areas where a disease is likely to be a problem. Losses greater than 50 per cent are possible, and the increase in inoculum will create problems for other growers.

FURTHER INFORMATION

Victorian Cereal Diseases Guide

agriculture.vic.gov.au/cereal-disease-guide

Victorian Pulse Diseases Guide

agriculture.vic.gov.au//pulse-disease-guide

Victorian Crop Sowing Guide

agriculture.vic.gov.au/crops-and-horticulture/grains-pulses-and-cereals/crop-production/general-agronomy/victorian-crop-sowing-guide

Canola Ratings

grdc.com.au/GRDC-FS-BlacklegManagementGuide

Other variety guides (i.e. Western Australia)

grdc.com.au/resources-and-publications/all-publications/nvt-crop-sowing-guides

FOLIAR DISEASES OF WHEAT

Author: Dr Grant Hollaway (Agriculture Victoria)

INTRODUCTION

There are a range of foliar diseases that need to be considered when growing wheat. The more important foliar diseases of wheat in Victoria are the rusts (Stripe rust, Leaf rust and Stem rust), Septoria tritici blotch, Powdery mildew, and Yellow leaf spot. The relative importance of each of these diseases is dependent on the degree of resistance in a crop, the amount of inoculum present in a paddock or district, and the local seasonal conditions. Fortunately, growers have access to a range of strategies to minimise losses (both in grain yield and grain quality) associated with these diseases and the best control of foliar diseases is achieved when a combination of approaches are used.

Generally, long term control of the important foliar diseases of wheat can be achieved when the growing of cultivars that are highly susceptible (i.e. those rated as Susceptible and Very Susceptible) to regionally important diseases is avoided (see Chapter two, Resistance Ratings). Fortunately, for all important foliar diseases of wheat there are varieties with resistance available. However, very few varieties have resistance to all foliar diseases. Therefore, growers need to be aware of the priority diseases for their region and where adequate resistance is not available implement additional control strategies.

Strategies that minimise inoculum levels can help reduce the impact of foliar diseases during a season. For the rusts, which can only survive from one season to the next on living plants (particularly wheat) controlling volunteers growing over summer and autumn can decrease inoculum carry over. For stubble borne diseases (e.g. Yellow leaf spot), avoiding planting into infected wheat stubble can contribute to reducing the impact of these diseases.

For all foliar diseases of wheat there are fungicide control options available. However, it is important not to rely on fungicides as the only control option and use strategies that minimise the likelihood of resistance to fungicides developing (see Chapter 16, Fungicides). In general fungicides provide the best control outcome when applied early in a disease epidemic and used as part of an integrated disease management strategy.

Following the identification and control of each of the important foliar diseases of wheat in Victoria is discussed.

Leaf Rust *Stem Rust* *Stripe Rust*

Figure 3.1. Distinguishing symptoms of leaf, stem, and stripe rust of wheat

STRIPE RUST OF WHEAT

Stripe rust is currently the most common of the three rusts in Victoria, with suitable conditions for rust occurring in most seasons. The importance of stripe rust is usually related to the proportion of susceptible cultivars being grown and the opportunity for carry over of inoculum during the summer.

Since the first introduction of wheat Stripe rust into Australia in 1979 there have been a further three introductions (2002, 2017 and 2018) of significance. Three of these incursions may have originated from Europe (1979, 2017 and 2018) while North America (2002) was implicated as the source of the other.

Over time these introductions undergo mutations which result in increased virulence (ability to attack more resistance genes) and in some cases will displace older pathotypes. In some seasons a single Stripe rust pathotype will predominate while in other seasons there will be a range of pathotypes present. For example, during 2020, the University of Sydney's pathotype surveillance detected approximately seven different strains of wheat Stripe rust in eastern Australia.

The resistance ratings provided in Victorian Cereal Disease Guide and the NVT website represent the dominant and most virulent of the pathotypes present in Victoria.

What to Look For

Stripe rust is easiest to identify in the morning. Examine leaves, especially the older leaves, low in the canopy and look for yellow stripes of pustules (Figure 3.1). These pustules are raised above the leaf surface and can be easily wiped off onto a white cloth or tissue leaving a yellow stain. Also watch for hot spots in the crop. Hot spots are 1-10 metres in diameter and are generally well developed just before the disease becomes widespread in the crop.

Disease Cycle

Stripe rust is caused by the fungus *Puccinia striiformis*. Stripe rust survives from one season to the next predominantly on volunteer self-sown wheat and to a lesser extent on other cereal and grass weeds that grow over summer and is known as the 'green bridge' (Figure 3.2). Consequently Stripe rust epidemics are usually more severe in seasons following wet summers.

During the growing season, conditions suitable for epidemic development occur from April to December in Victoria and Stripe rust can be expected in crops by late August or early September in most years. For an infection of a plant to occur the spore requires temperatures of less than 18°C (optimum 6-12°C) with a minimum of three hours of leaf-wetness (i.e dew). Once an infection is established within the leaf the fungus can survive short periods of temperatures as high as 40°C.

Following infection of the leaf, the fungus grows without symptoms within the leaf for 14 to 28 days (or longer depending on temperature) until the spores appear on the leaf surface as pustules. The time between initial infection and symptom development is known as the latent period, with this time reducing as temperatures warm during the spring. The spores are then spread by wind, allowing the cycle to repeat multiple times during the season. Spores can spread long distances on the wind (i.e. 100's of km).

Stripe Rust Management

Stripe rust can cause significant loss to grain yield and quality, given appropriate environmental conditions and susceptible varieties. However, farmers have shown that by planning to manage this disease they can effectively minimise its impact.

The most appropriate Stripe rust management strategy will vary from one farm to another, from region to region, and from season to season.

The following management strategies are recommended to minimise the impact of Stripe rust:

- remove volunteer wheat plants (the 'green bridge') that will support Stripe rust inoculum in the 6 weeks prior to sowing
- avoid Very Susceptible (VS) and Susceptible (S) varieties by selecting more resistant varieties
- use a seed or fertiliser applied fungicide treatment with activity on Stripe rust to suppress early infection
- monitor crops during the growing season and apply a foliar fungicide early in the epidemic, if required.

The Green Bridge

Stripe rust can only survive from one season to the next on living plants; mostly wheat and to a lesser extent barley, triticale, barley grass, brome grass and phalaris. This is called the 'green bridge'.

Stripe rust does not survive on seed, stubble or soil. Therefore, the greater the number of susceptible volunteer wheat plants growing during summer/autumn the greater the risk of a Stripe rust epidemic and the reason that Stripe rust is usually more severe following wet summers.

The susceptibility of the volunteer wheat plants over summer influences the quantity of inoculum generated by the green bridge. If most varieties in a district are resistant there will be considerably less inoculum than if the majority of plants are susceptible or very susceptible.

It is critical that all volunteer wheat plants are removed either by spraying, cultivation or heavy grazing by the end of March. Particular care should be taken to destroy plants around sheds and silos, as Stripe rust often survives on these plants.

Variety Selection

Avoiding varieties susceptible to Stripe rust is the primary strategy for management. As shown in Figure 3.3 the potential yield loss from Stripe rust drops dramatically as the resistance in a variety improves. The actual disease response that occurs in the field will depend on many factors including the amount of inoculum carry over, the timing of the rust outbreak in the crop and the pathotypes (races/strains) of Stripe rust occurring in a region. See Chapter two for more information on resistance ratings.

Stripe rust resistance ratings are determined by multi-site field screening conducted nationally through the GRDC's NVT disease screening program. The disease resistance ratings are updated annually and published in the Victorian cereal disease guide and on the NVT website. Since Stripe rust pathotypes (strains) are known to change over time, it is critical that only current disease ratings are used.

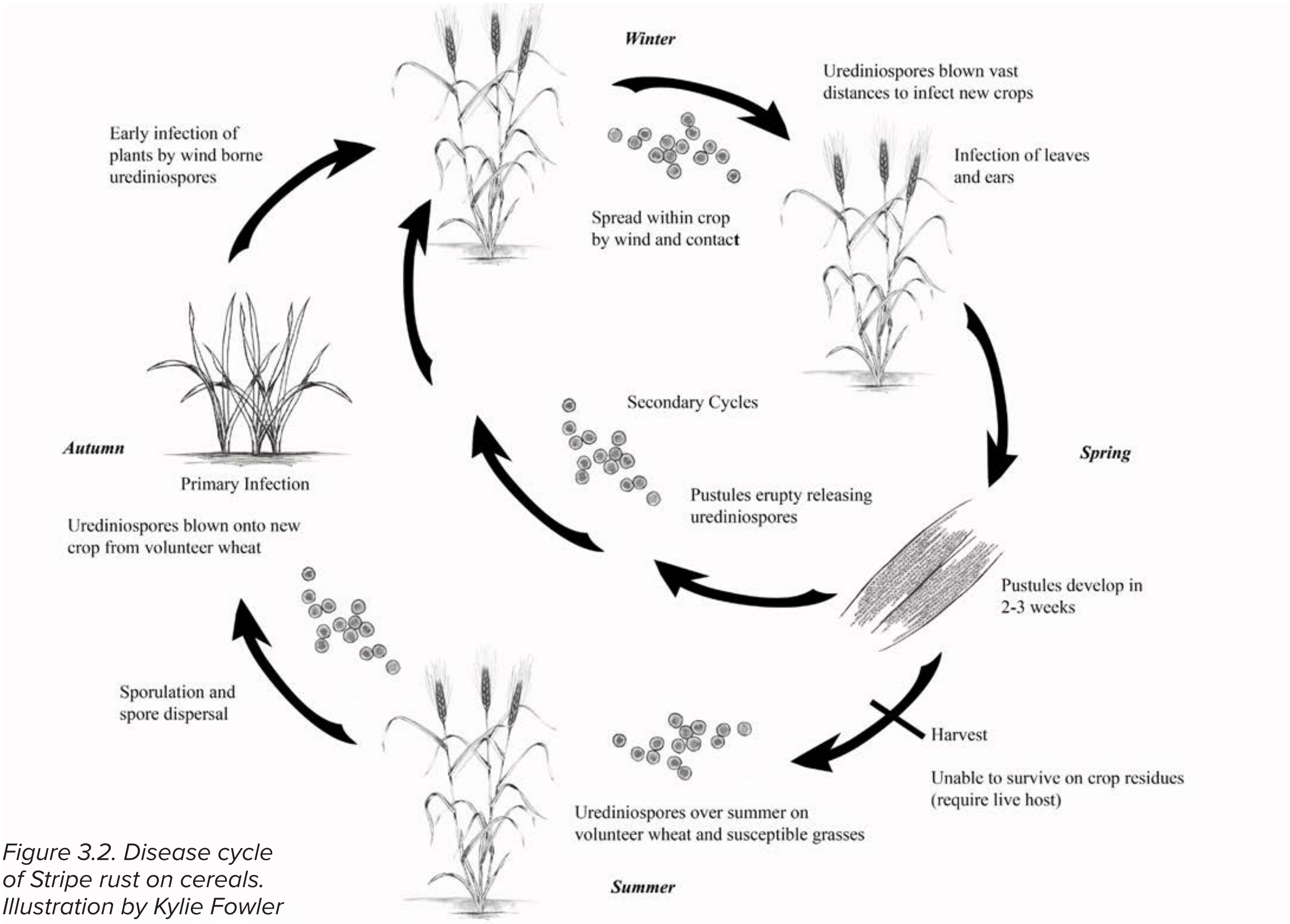


Figure 3.2. Disease cycle of Stripe rust on cereals. Illustration by Kylie Fowler

Varieties rated as Very Susceptible (VS) or Susceptible (S) to Stripe rust should be avoided. In such varieties Stripe rust is more difficult to manage, especially if the season is favourable for Stripe rust. VS and S varieties have the potential to rapidly lose all leaf area to Stripe rust.

The build-up of rust on these varieties can lead to infection of other crops in the district and increases the chance of mutations resulting in resistance break down occurring.

If VS or S varieties are grown it is important that seed or fertiliser is treated with a fungicide before sowing. Crops of VS and S varieties should be monitored regularly for the first sign of rust and a fungicide applied when necessary.

Varieties rated as Moderately Resistant to Moderately Susceptible (MRMS) or Moderately Susceptible (MS) generally have adult plant resistance. These varieties are unlikely to lose all their flag leaf to disease but may need a fungicide spray if rust is detected early (before flag emergence).

Varieties rated Moderately Resistant (MR) show only limited rust symptoms on their flag leaves under ideal rust conditions. Varieties rated as Resistant (R) are those with resistance which persists for the duration of the plant's life. Even varieties rated as MR and R should be monitored with a view to fungicide application in case a new or minor strain of the rust that is able to overcome the resistance has appeared.

Fungicides

Seed and fertiliser fungicide treatments play an important role in Stripe rust management. In the Wimmera, Western, Central and North East districts all varieties with a Stripe rust rating of MRMS or lower should be treated with either a seed or fertiliser treatment to suppress early Stripe rust. In the Mallee, growers should use a seed or fertiliser treatment that suppresses early infection in crops when there is a high carry over of inoculum on the green bridge and when susceptible varieties are grown.

These treatments will be most effective when adopted across a region as they will greatly reduce the inoculum levels in a district. The length of protection varies depending on the product selected and seasonal conditions.

Note that fertiliser treatments do not control bunts and smuts, so a seed treatment still needs to be applied to the seed (see Bunts and Smuts of Cereals). Where crops are sown early for anticipated grazing benefits, issues such as withholding period will also need to be considered.

Crops treated with a seed or fertiliser treatment should still be monitored during the season with a view to a foliar application, if necessary, especially when susceptible cultivars are grown.

Foliar fungicides for controlling Stripe rust should be regarded as a support and not a substitute for growing resistant varieties.

The requirement for fungicide sprays will depend on the carry-over of rust inoculum on the 'green bridge', the timing of the epidemic (in relation to crop growth stage) and the level of resistance in the variety. For example, in seasons where Stripe rust is detected early (i.e. tillering to flag), a fungicide spray will be required in many varieties to protect green leaf area until the onset of adult plant resistance (APR), which starts around ear emergence. Varieties without effective APR may require sprays beyond ear emergence. Sprays are generally more effective when applied early in an epidemic.

It is likely that the onset of a rust epidemic will be different in different years. The timing of the first occurrence in the crop may be different and the district where it first occurs may also be different. Therefore, it is important that the decision to apply fungicides is based on current seasonal and crop conditions and is not based on previous experiences alone.

During the season, crops should be monitored regularly (at least every two weeks) for the presence of stripe rust. The earlier that rust occurs within a crop the greater the potential loss, though the easier it is to control.

It is important to note that in Susceptible (S), Susceptible to Very Susceptible (SVS) and Very Susceptible (VS) cultivars, rust can develop very quickly (Figure 3.4). Consequently, fungicides should be applied as a preventative and don't wait until rust is obvious.

If Stripe rust is present before ear emergence, then crops must be sprayed before the level of infection reaches 1 per cent leaf area affected (i.e. when approximately 35 leaves per 100 have Stripe rust). It is better to spray sooner rather than later.

When Stripe rust is first detected at ear emergence, only the most susceptible (S, SVS and VS) crops or longer season crops may need spraying. After a fungicide application crops should continue to be monitored as fungicides only provide between two to four weeks protection.

There is often an apparent increase in Stripe rust for a few days after spraying. This is caused by the development of symptoms of infections that occurred just before spraying. Control becomes apparent within a week of spraying, and the period of protection is normally about four weeks.

To support in-crop decision making for Stripe rust management a new tablet-based app, 'StripeRustWM' developed by the Department of Primary Industries and Regional Development (DPIRD) and GRDC, was released in 2020. StripeRustWM uses information, including variety resistance rating, plant growth stage, presence of rust either within the crop or the district and expected yield to estimate potential losses. It's available free for iPads and Android tablets from the Apple App Store and Google Play.

Note: products containing tebuconazole break down relatively slowly in plants and users must observe the product label restrictions regarding the total amount that can be applied to one crop per season. This will ensure harvested crops don't exceed the tebuconazole maximum residue limit (MRL) in cereal grains.

Early Season Protection Vs. Foliar Sprays

There has been much discussion as to the relative merits of early season protection (i.e. applying early season seed or fertiliser treatments, with follow up fungicide spray if required) versus relying only on applications of foliar fungicides. Both approaches can effectively manage Stripe rust, with similar costs to the grower, if used appropriately.

The disadvantage of early season protection is that expense is incurred before knowing if rust is an issue or the yield potential of the crop. The advantage of the early applied long season protection is that in the presence of rust, the likelihood that a fungicide will be required before flag leaf emergence Is greatly reduced. This minimises the need for timely fungicide applications during the season.

The disadvantage of the foliar spray option alone is that crops must be sprayed early in the rust epidemic, in a timely fashion, keeping in mind the difficulty of spraying during periods of continuous wet weather and other farm operational requirements at the time. The advantage of this approach is that expense is only incurred when, and if, Stripe rust is an issue within the crop. Both methods are effective if used appropriately. To determine which approach is the most suitable, growers need to consider rust carry over on the green bridge, variety selection, local conditions and the ability to spray for Stripe rust in a timely fashion.

Resistance to Stripe Rust in Wheat

In general, there are two types of resistance to Stripe rust deployed in Australian wheats. They are major gene resistance (also known as all stage resistance) and adult plant resistance. These resistance sources may be used either alone or in combination within a variety.

All Stage Resistance (Major Gene Resistance)

All stage resistance (also known as major gene resistance) is effective during the whole life of the plant. Usually, this resistance is strain (pathotype) specific and is very effective against some strains of rust, though ineffective against others. Typically, when these major genes are first deployed, they are completely effective, but through mutation of the rust these resistances may be short lived in wheat should they be overcome or 'broken down' by the pathogen. An example of this is the acquisition of virulence toward the Yr17 gene deployed in many varieties.

When a major resistance gene is 'broken down' the level of resistance in a variety will depend on the other genes present in that variety.

Adult Plant Resistance (APR)

APR is a resistance that is widely used in Australian wheats. APR genes are often partial resistance genes that work by slowing down the rate of rust development. They do not stop the disease progress completely.

There are a number of APR genes used in Australian commercial wheats. The relative effectiveness of APR genes can be influenced by factors such as the:

- temperature; APR often working better at higher temperatures
- crop nitrogen status; there may be a delayed onset in high nitrogen status crops
- wheat variety that they are deployed in
- number of APR genes present; their effects may be additive
- pathotypes of Stripe rust present, in some instances.

Even though APR genes are widely used in Australian wheat varieties they are often not well understood. Some APR genes

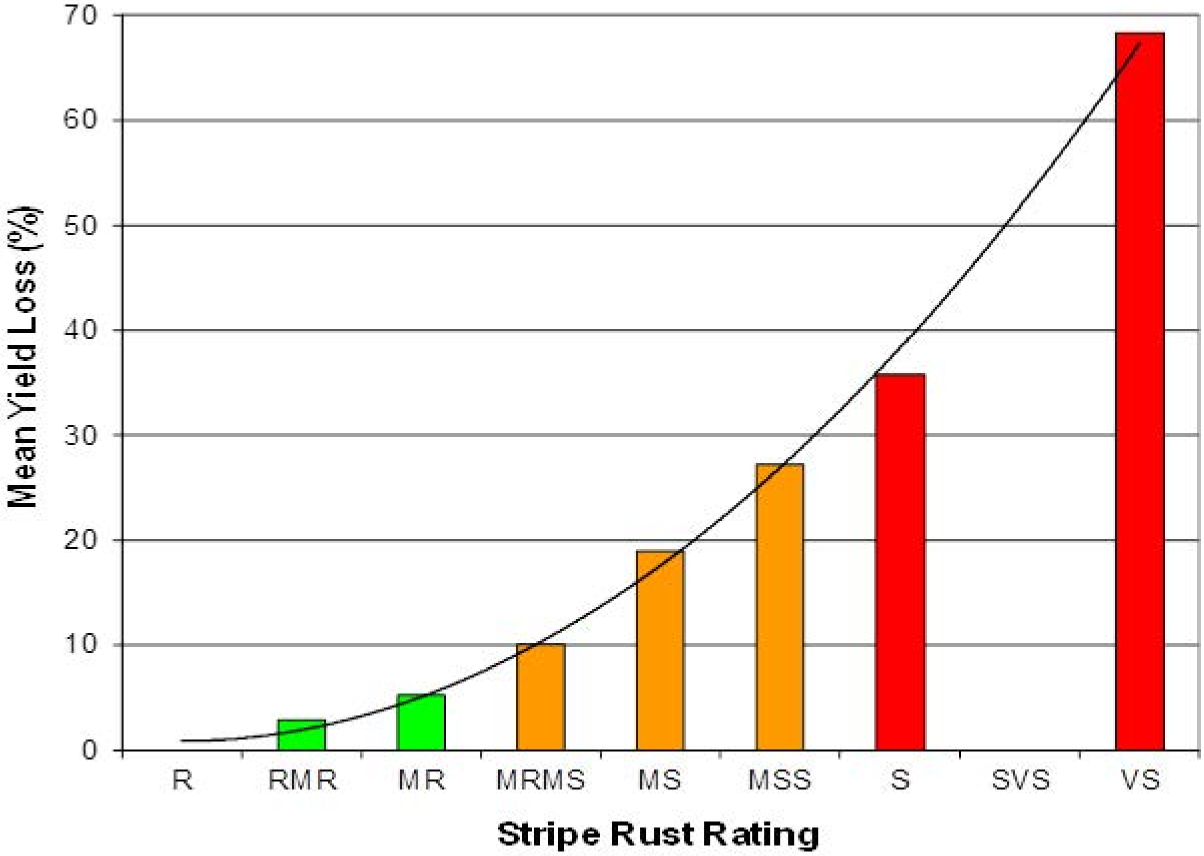


Figure 3.3. Yield loss in wheat varieties with different stripe rust ratings

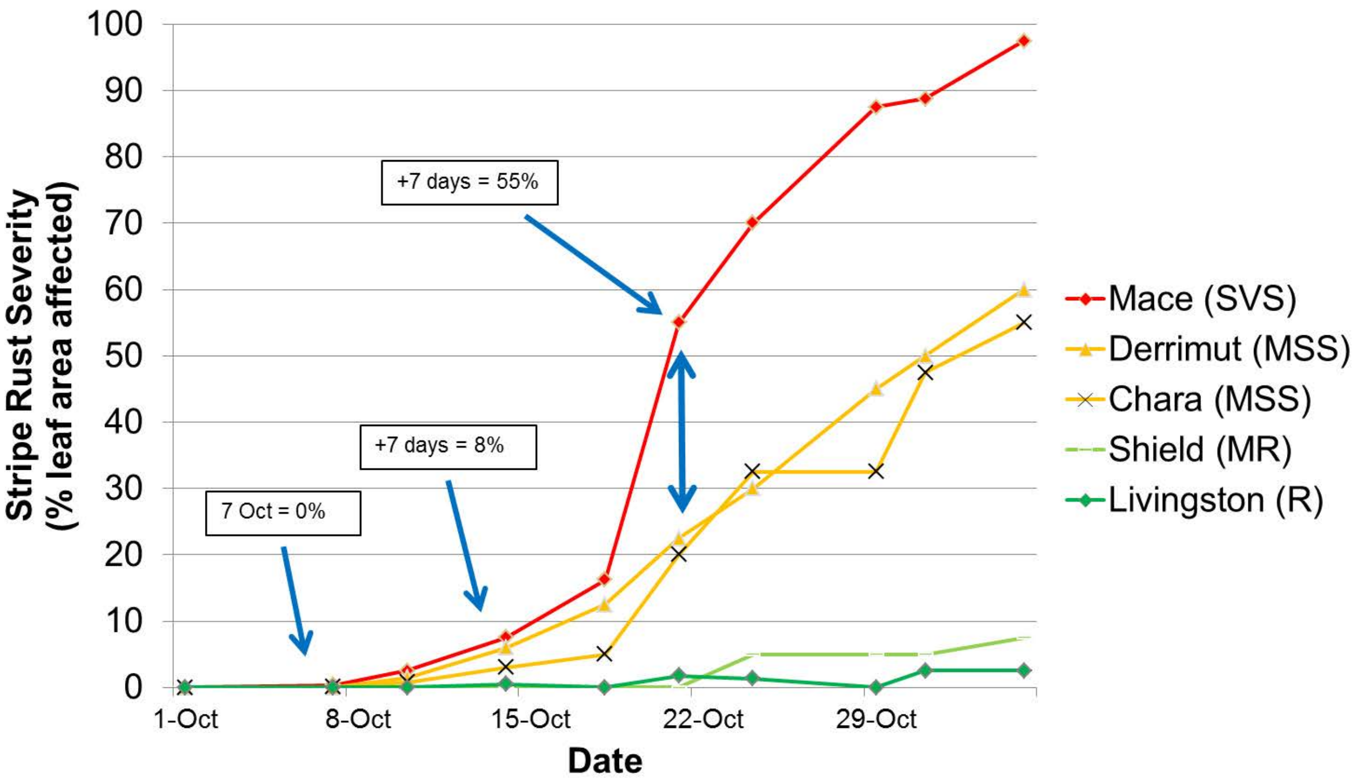


Figure 3.4. Stripe rust progress at Horsham during 2013 in 5 cultivars with different resistance/susceptibility to stripe rust (data collected by Joshua Fanning — Agriculture Victoria)

may also be pathotype specific making them prone to being overcome by new pathotypes of Stripe rust, while other APR genes are regarded as 'durable' and less likely to be overcome by new pathotypes. In general, APR becomes effective at around ear emergence and works best if rust levels are not excessive in the crop at this time.

In varieties that have APR as their only source of resistance (typically varieties with intermediate resistance ratings) it may be important to protect the earlier growth stages of the crop with seed or fertiliser treatments and/or fungicide sprays. In general, varieties rated as MS and above with effective APR will rarely lose all their flag leaf to disease, whereas varieties rated S to VS are at risk of losing 100 per cent of their leaf area to disease.

Many cultivars with APR can be very susceptible as young plants. Growers using such varieties must plan to protect their young crops from Stripe rust before the APR becomes effective to minimise rust build up. The level of susceptibility of young crops will vary from one variety to another. This early susceptibility of young crops can result in build-up of rust in some years.

The Australian Cereal Rust Control Program, based at the University of Sydney and supported by the GRDC, conducts annual monitoring of cereal rust pathotypes (strains) present in Australia. The information on the pathotypes present in Australia is crucial in determining how varieties will perform to the dominant rusts present in Australia. Details on how to submit rust samples for pathotyping and to view pathotyping results see Further Information.

LEAF RUST OF WHEAT

Compared to Stripe and Stem rust, Leaf rust is potentially the least damaging in susceptible varieties, but in most seasons, conditions are conducive for this disease to develop. In Victoria, severe Leaf rust infections can reduce grain yield by more than 20 per cent in susceptible varieties and can also reduce grain quality. Leaf rust is effectively controlled when resistant varieties are grown, but when susceptible varieties are grown protection with fungicides may be required.

Recent detections of new pathotypes of Leaf rust means that many important cultivars have poor levels of resistance to Leaf rust.

What to Look For

Leaf rust is a relatively easy disease to diagnose as it forms orange-brown pustules that are raised above the leaf surface (Figure 3.5). These pustules can be rubbed off the leaf leaving an orange-brown mark on the finger. The pustules which are scattered across the leaf surface are circular to oval in shape and confined chiefly to the upper surface of the leaf.

Later in the season, black teliospores develop on mature plants, usually on the under surface of the leaf or on the leaf sheath. These black spores are not of concern.

Disease Cycle

Leaf rust is caused by the fungus *Puccinia triticina* (formally *Puccinia recondita*). Leaf rust, like other cereal rusts, requires a living host to survive from one season to the next (Figure 3.6).

The most important hosts for Leaf rust are susceptible volunteer wheat plants growing during the summer/autumn. Rust cannot carry over from one season to the next on seed, stubble or soil.

Wheat varieties susceptible to Leaf rust enable inoculum levels to build up on volunteers during the summer and autumn. This can be a problem in seasons following wet summers that favour the growth of self-sown wheat. The plants that become heavily infected with rust in the autumn provide a source of rust for the new season's wheat crop. If these conditions are followed by a mild winter and a warm wet spring, then the chances of a Leaf rust epidemic are high. Therefore, the chances of a rust epidemic are greatest following a wet summer.

In Australia, due to the absence of an alternate host, Leaf rust can only reproduce asexually. This reduces the genetic variability within the Leaf rust population and therefore increases the likelihood that resistant varieties will be effective for a long period of time.

Rust spores are wind-blown and can be spread over large areas in a short time. The establishment of Leaf rust epidemics within a crop is favoured by wet conditions and temperatures of approximately 15-22°C.

Leaf Rust Management

Cultural Practices

Heavy grazing, or the use of herbicides, during autumn to remove self-sown susceptible wheat (the green bridge) will reduce the amount of rust in following crops. However, if spring conditions are favourable for Leaf rust development, then even small amounts of rust that survived the autumn can multiply to cause serious yield losses in the spring.

Figure 3.5. Leaf rust of wheat symptoms

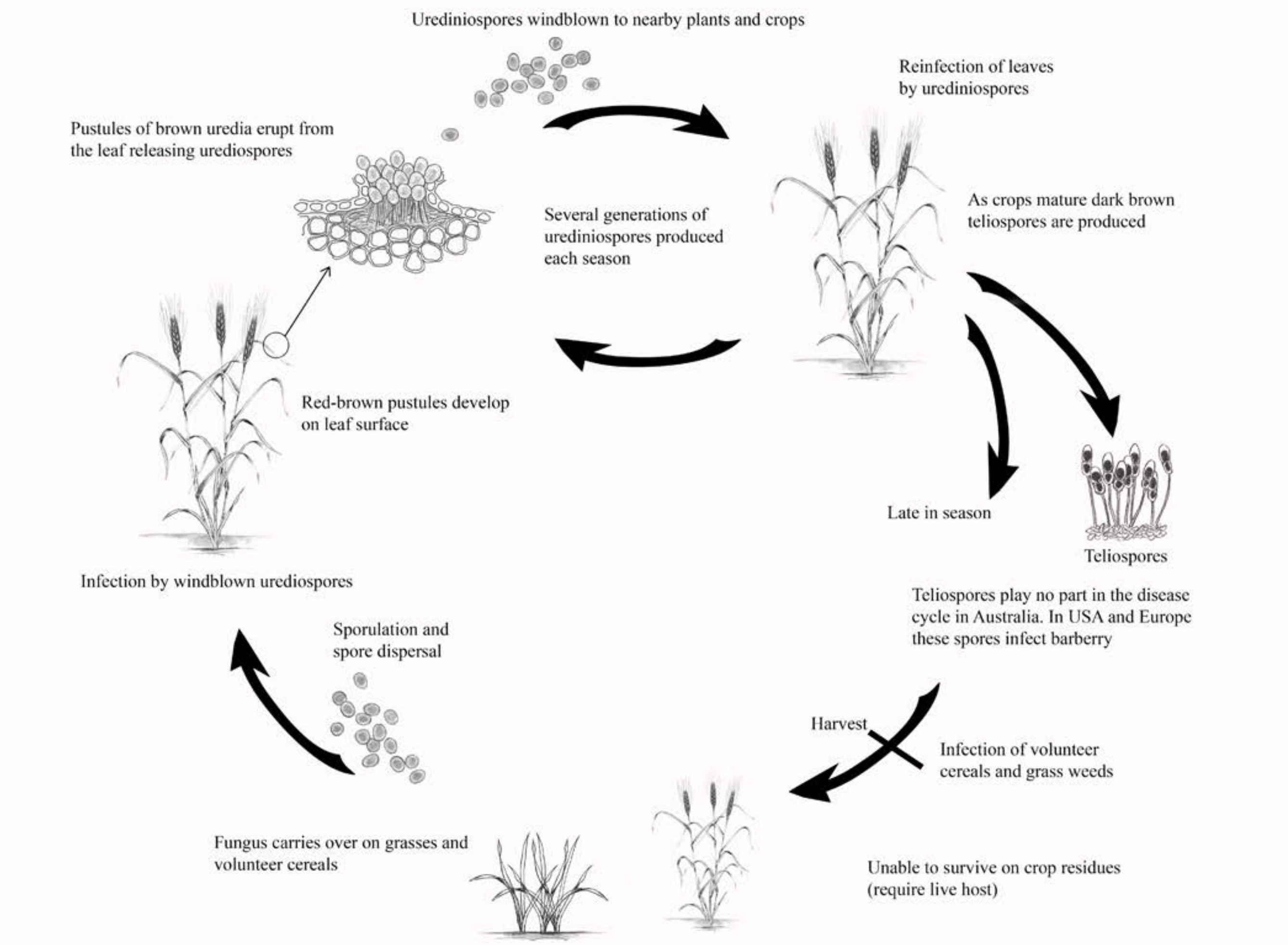


Figure 3.6. Disease cycle of leaf rust on cereals. Illustration by Kylie Fowler

Variety selection

The best way to manage Leaf rust is to avoid susceptible varieties. When most wheat varieties are resistant long term control can be achieved.

However, Leaf rust through chance mutation or exotic introduction can produce new races which are capable of attacking varieties that were resistant when they were first released. Widespread cultivation of resistant varieties minimises the levels of rust in the environment and reduces the occurrence of new races.

It is important that growers are aware of their varieties' disease resistance to Leaf rust. Variety resistance ratings are available in the Victorian Cereal Disease Guide and on the NVT website. It is important to use a current disease guide as mutations occur in rust from time to time and resistant ratings are adjusted accordingly.

Seed Treatments

There are seed treatments available which will suppress early infections of Leaf rust. Seed treatments are important in susceptible varieties, especially if they are sown early or following a wet summer favouring growth of volunteers.

Foliar Fungicides

There are many foliar fungicides registered for the control of Leaf rust in wheat. Fungicides should not be regarded as a substitute for growing resistant varieties. They are more of a backup for when a new race of rust evolves and for use in regions where adequate resistance is not available. A fungicide response is unlikely in Resistant (R) or Moderately Resistant (MR) rated varieties.

Like the other rusts it is important to apply fungicides early in the epidemic. If a severe epidemic develops early in the season in a susceptible variety then it may be necessary to make two applications of fungicide. Leaf rust first appearing after ear emergence is less likely to have a significant impact on grain yield.

Leaf Rust Pathotype Monitoring

The Australian Cereal Rust Control Program, based at the University of Sydney and supported by the GRDC, conducts annual monitoring of cereal rust pathotypes (strains) present in Australia. The information on the pathotypes present in Australia is crucial in determining how varieties will perform to the dominant rusts present in Australia. Details on how to submit rust samples for pathotyping, to view pathotyping results, and maps, see Further Information.

STEM RUST OF WHEAT

Stem rust is an occasional, but devastating disease of wheat.

Conditions that favour Stem rust epidemics are rare and occur on average once every 16 years in Victoria. However, when conditions are conducive, the disease can cause complete crop loss in susceptible varieties.

Historically, the most severe epidemics in Victoria occurred (in descending order of severity) in 1973, 1947, 1934 and 1955. In 1973, Stem rust reduced the Victorian wheat harvest by 25 per cent. It is unlikely that Stem rust losses will ever be as severe as in 1973 due to the increased cultivation of Stem rust resistant varieties and the greater availability of effective foliar fungicides. In recent years, there have been few localised occurrences of Stem rust.

Following the exceptionally wet January of 2011 there was a large amount of inoculum carry over that resulted in widespread Stem rust in Victoria during that year. In spite of this, the widespread preventative use of fungicides helped minimise losses in that year.

What to Look For

Stem rust is characterised by reddish-brown, powdery, oblong pustules. The pustules have a characteristic torn margin that can occur on both sides of the leaves, on the stems and the glumes. Stem rust spores are much darker in colour than leaf or Stripe rust spores.

As the plant matures, the pustules produce black spores known as teliospores. They occur mainly on the leaf sheaths and stem but are most obvious on the stems (Figure 3.8).

Disease Cycle

Stem rust (caused by the fungus *Puccinia graminis*) can only survive from one season to the next on a living host. It does not survive on stubble, seed or soil. The most important hosts are susceptible wheat, but it can also survive on barley, triticale and some grasses. Carry over on wheat from one season to the next is greatest during wet summer/autumns (Figure 3.7).

Rust spores are wind-blown and can be spread over large areas (>1,000km) in a short time. Wet conditions and temperatures of approximately 15-30°C favour the establishment of Stem rust within crops which means Stem rust usually becomes evident later in the season than Stripe rust as it prefers warmer temperatures.

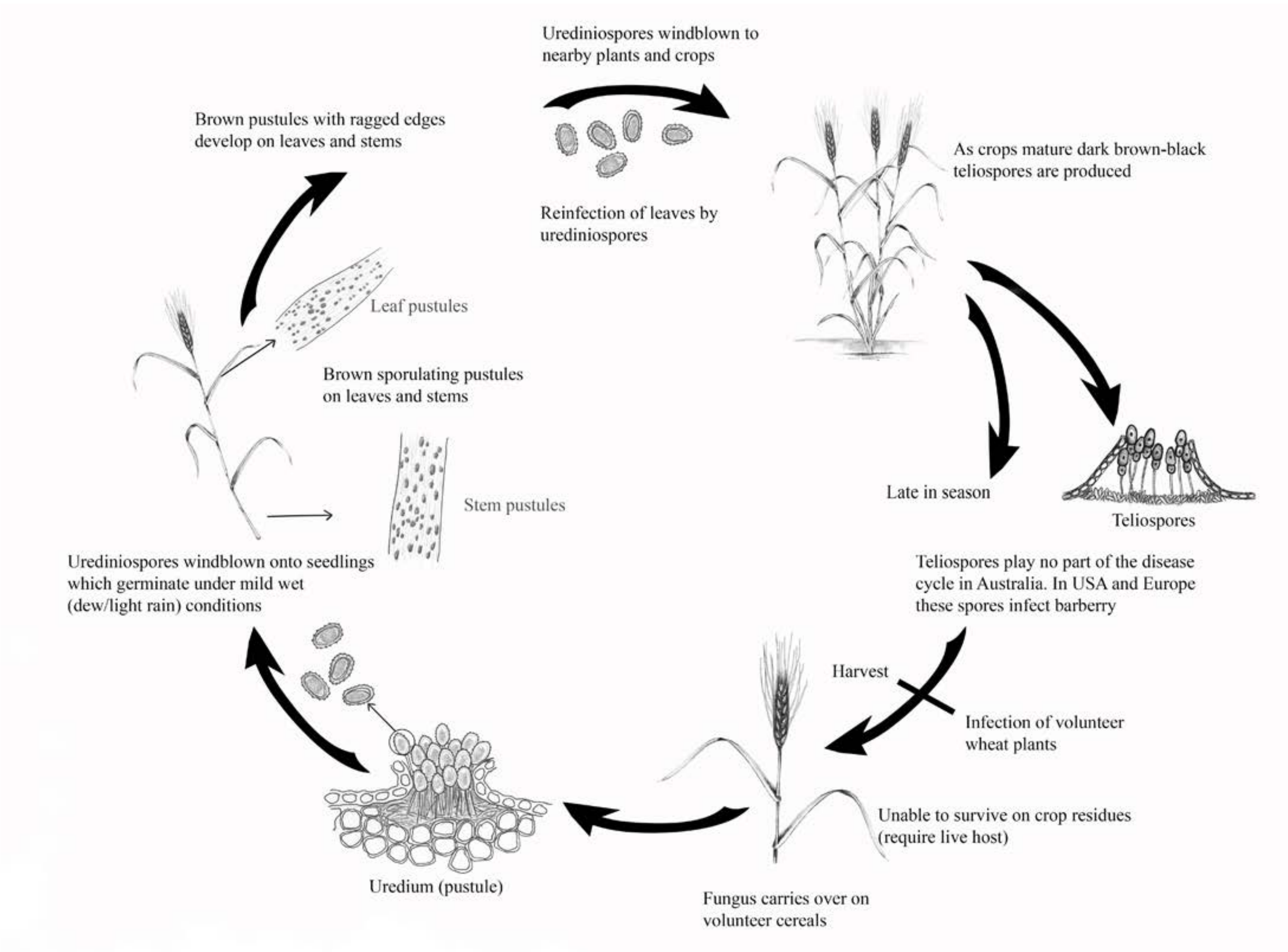


Figure 3.7. Disease cycle stem rust on cereals. Illustration by Kylie Fowler

Management

Conditions Favourable to Stem Rust

Stem rust can occur in all regions of Victoria where susceptible varieties are grown. However, the likelihood of a Stem rust epidemic is increased by several factors:

- the build-up of Stem rust inoculum on volunteer wheat before sowing, both locally and in neighbouring states
- the widespread planting of susceptible varieties
- favourable weather conditions, which includes good spring rains and warm (15-30°C) humid conditions
- If the first two conditions above are met and there is a wet spring, an outbreak is likely to occur.

Pre-Season Management of Stem Rust

Stem rust can be managed using an integrated approach. This includes reducing the inoculum in a district by managing the green bridge, avoiding susceptible cultivars and close monitoring to enable timely fungicide sprays.

The Green Bridge

Rust can only survive from one season to the next on living plant material (mainly self-sown cereals). Therefore, the removal of the green bridge is essential to reduce the amount of inoculum present to infect a new crop. This is why Stem rust epidemics have been worse following wet summer/autumns that favour volunteer cereal growth.

Variety Selection

Sowing resistant varieties provides the best protection against Stem rust. In most parts of Victoria, Stem rust has been controlled because of the use of resistant varieties.

Stem rust occasionally produces new pathotypes (races) which are capable of attacking resistant varieties. These new pathotypes occur when a chance mutation occurs in this asexually reproducing fungus. Use of resistant varieties minimises the amount of rust in a district, thus reducing the chance of new pathotypes occurring. It is important that growers are aware of a variety's resistance reaction to Stem rust. For a comprehensive list of varieties, consult a current Victorian Cereal Disease Guide.

In Crop Management of Stem Rust

The effects of Stem rust can be minimised with the timely application of foliar fungicides. As there is limited information on the management of Stem rust in Victoria, the following recommendations for the in-crop management of Stem rust are based on experience in Western Australia (Jayasena et al 2015).

Monitoring

Stem rust is most severe in susceptible varieties when it begins to develop in the crop before flowering with crop losses of 50 per cent possible. Yield losses from later infections are possible, but not as severe.

As Stem rust requires warmer conditions than Stripe rust for development, it is advisable to begin monitoring for Stem rust from flag leaf emergence onwards. Monitoring will be necessary in seasons when Stem rust has been detected locally or on volunteer plants before sowing.

Inspect wheat crops every 7 to 10 days from flag leaf emergence to early dough grain development. However, if Stem rust is detected within a region, then increase inspection frequency to every 4 to 7 days.

Carefully inspect different plant parts, especially the lower stems, for symptoms of Stem rust. Spend at least 15 minutes walking through each wheat crop.

If Stem rust is detected, walk through the paddock in a 'W' pattern and collect 10 stems from 10 random locations (total 100) to determine the percentage of Stem rust infection.

Table 3.1. A guide for timing fungicide control of stem rust (adapted from Jayasena et al 2015)

CROP GROWTH STAGE	STEMS INFECTED[A] %	RESISTANCE RATING[B]	
		VS, S, MSS	MRMS
Before ear emergence	1-5	Spray	Monitor
	>5	Spray	Spray
Ear emergence / mid dough	>5	Spray	Monitor
	>50	Spray	Spray

(A) Based on 100 stems selected in a W pattern across crop.

(B) R= Resistant, MR = Moderately Resistant, MS = Moderately Susceptible, S = Susceptible, VS = Very Susceptible

***Note**: this table is not based on Victorian data, but on limited experimental data from Western Australia (Jayasena et al 2015). Fungicides will give better control of stem rust when applied early in the epidemic. A late, low level occurrence of stem rust (i.e. after mid-dough) will have little impact on yield.*

When to Spray

The information in Table 3.1 is a guide for the application of foliar fungicides.

In 2011, when there were paddocks of self-sown wheat heavily infected with Stem rust at sowing, the prophylactic application of fungicides to susceptible varieties was important for the area-wide control of this disease. Such an approach would not be warranted in most seasons.

Choice of Fungicide

In Victoria, there are a number of active ingredients (available in a range of products) registered for the control of Stem rust.

It is always important to read the chemical label before use. In particular, check that the product is registered and use the maximum recommended label rate for Stem rust control in wheat.

Note: *products containing tebuconazole break down relatively slowly in plants and users must observe the product label restrictions regarding the total amount that can be applied to one crop per season. This will ensure harvested crops don't exceed the tebuconazole maximum residue limit (MRL) in cereal grains. As sprays for Stem rust may be applied late in the season, it is extremely important to know the harvest withholding period for the chemicals, which can vary from 4 to 6 weeks.*

Stem Rust Pathotype Monitoring

The Australian Cereal Rust Control Program, based at the University of Sydney and supported by the GRDC, conducts annual monitoring of cereal rust pathotypes (strains) present in Australia. The information on the pathotypes present in Australia is crucial in determining how varieties will perform to the dominant rusts present in Australia. Details on how to submit rust samples for pathotyping, to view pathotyping results, and maps, see Further Information.

Figure 3.8. Stem rust of wheat.

YELLOW (LEAF) SPOT

Yellow leaf spot, also known as tan spot, is a widespread and important disease of wheat in Victoria. It is supported by stubble retention, intense wheat production in the rotation and widespread cultivation of susceptible wheat varieties.

In most years, Yellow leaf spot only infects the lower leaves and is generally regarded as causing limited yield loss. However, in wet seasons (e.g. 2016) when susceptible wheat varieties are sown into wheat stubble, heavy infestations of Yellow leaf spot can cause yield loss (up to 25 per cent) when the flag and upper leaves become infected.

What to Look For

Yellow leaf spot is most often observed in seedlings, but when conditions are suitable (i.e. wet conditions) it can progress up the plant.

The first symptoms appear on leaves as small tan oval spots or lesions surrounded by a yellow halo (Figure 3.9).

Individual lesions may vary in shape and size, often expanding and joining together with other lesions. The tips of severely affected leaves soon yellow and die (Figures 3.10 & 3.11).

Accurate disease identification is important as symptoms of Yellow leaf spot can be confused with other disorders like aluminium toxicity or herbicide damage.

Figure 3.9. Early symptoms of Yellow leaf spot infection

Figure 3.10. Yellow leaf spot infections on older leaves, leaf tips dying

Figure 3.11. Severe Yellow leaf spot infections on mature plants

Disease Cycle

Yellow leaf spot, caused by the fungus *Pyrenophora tritici-repentis*, is predominantly a stubble-borne disease. The fungus survives from season to season on stubble and as the weather cools and rain occurs in autumn and late winter small black fruiting bodies will develop.

Fruiting bodies contain large numbers of ascospores which are forcibly ejected during humid conditions (Figure 3.12). Spores land on nearby wheat plants and will infect leaves if they remain wet for more than 6 hours. These ascospores have limited dispersal and typically only infect nearby plants within that paddock.

Often the early infection of seedlings does not progress to adult plants. However, when conditions are wet during the season and temperatures are between 10-25°C a second type of spore (conidia) is produced on the infected leaves. This secondary spore is dispersed by the wind and can result in rapid disease development higher up the plant, as well as into other wheat crops in the area (Figure 3.13). It is this secondary spread that causes higher yield losses.

Figure 3.12. Black fruiting bodies of the yellow leaf spot fungus on stubble carry the disease from one year to the next

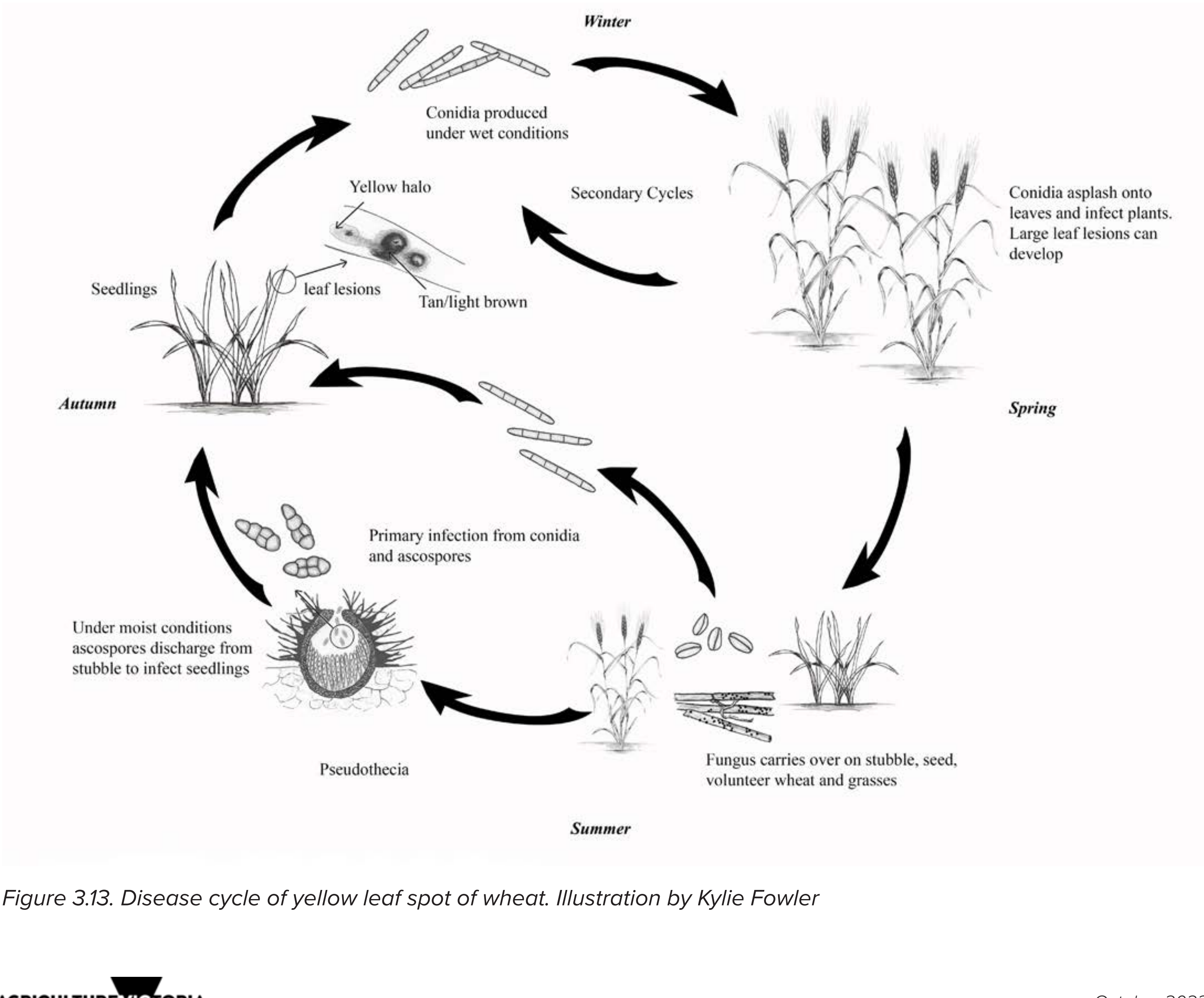


Figure 3.13. Disease cycle of yellow leaf spot of wheat. Illustration by Kylie Fowler

Yellow (Leaf) Spot Management

Yellow leaf spot is most severe where successive wheat crops are grown on retained stubble. Rotating wheat with barley, oats or a non-cereal crop will reduce the impact of this disease. Foliar fungicides are registered to control Yellow leaf spot, but they may not always be economical.

Management options include:

- Not sowing wheat into infected stubbles. A PREDICTA®B test that includes stubble with the soil can be used to identify paddocks at risk of Yellow leaf spot.
- Avoiding susceptible varieties. The pressure from Yellow leaf spot will be greatly reduced if Susceptible (S) and Very Susceptible varieties (VS) are replaced by varieties Moderately Susceptible (MS) or better to Yellow leaf spot. Complete resistance is not needed to achieve sustainable control of this disease. For current Yellow leaf spot resistance ratings see either the Victorian Cereal Disease Guide or the NVT website.
- Reducing the number of susceptible crops grown in a district will reduce inoculum load from season to season.
- Fungicides are most likely to give an economic return when yield potential is above 3.0 t/ha, a susceptible variety is being grown and 5 per cent of the Flag (-2) leaf and Flag (-3) leaf are affected. Under these conditions, a fungicide should be applied prior to, or just after rain. This will prevent the disease from moving up onto the flag leaf.

Seed and fertiliser treatments are not effective against this disease.

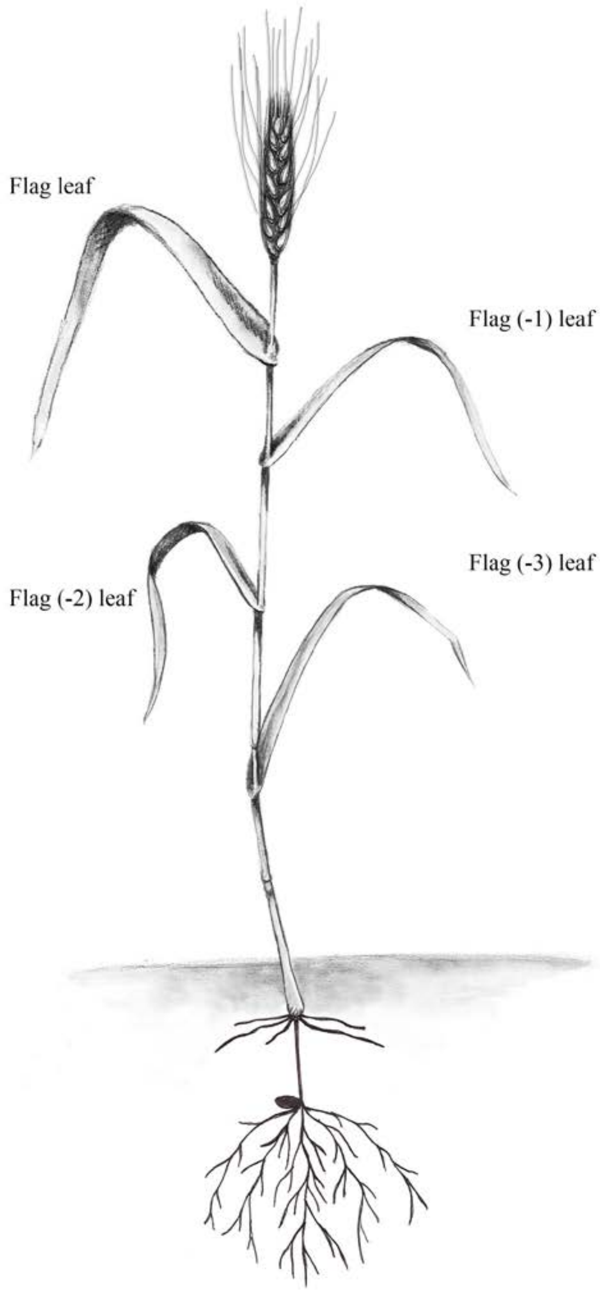


Figure 3.14. Cereal tiller showing leaf designations. Illustration by Kylie Fowler

SEPTORIA TRITICI BLOTCH OF WHEAT

Septoria tritici blotch (STB) is an important stubble borne foliar disease of wheat in Victoria. This disease has increased in importance in the high rainfall cropping regions of Victoria since 2012, after being well managed in Victoria for the previous 30 years through the use of partially resistant wheat varieties. The increase in STB in the high rainfall zone has been favoured by stubble retention, intensive wheat production, susceptible cultivars and the favourable environment for this disease.

When susceptible and very susceptible varieties are grown, Septoria tritici blotch is likely to cause annual average losses of up to 20 per cent, with much higher individual crop losses possible.

STB is prone to developing resistance to fungicides. Partial resistance to some triazole (Group 3) and resistance to strobilurin (Group 11) fungicides has been detected in eastern Australia. Therefore, strategies to minimise the further development of resistance is critical in an integrated approach to management.

Figure 3.15. The presence of black fruiting bodies within the blotches is a diagnostic feature of septoria tritici blotch. The only other disease that has similar symptoms is septoria nodorum blotch.

Figure 3.16. Septoria tritici blotch can cause complete death of leaves

What to Look For

The fungus causes pale grey to dark brown blotches on the leaves and to a lesser extent stems and heads. The diagnostic feature of Septoria tritici blotch is the presence of black fruiting bodies (pycnidia) within the blotches (Figure 3.15).

These tiny black spots give the blotches a characteristic speckled appearance. When the disease is severe, entire leaves may be affected by disease lesions (Figure 3.16).

In the absence of the black fruiting bodies, which are visible to the naked eye, similar blotching symptoms may be caused by Yellow leaf spot or a nutritional disorder such as aluminium toxicity or zinc deficiency.

The only other disease that has black fruiting bodies within the blotches is Septoria nodorum blotch (*Parastagonospora nodorum* synonyms *Stagonospora nodorum*, *Septoria nodorum*), but this disease is rare in Victoria.

Disease Cycle

Septoria tritici blotch, also called Septoria leaf spot or Speckled leaf blotch of wheat, is caused by the fungus *Zymoseptoria tritici* (synonym *Septoria tritici*).

Septoria tritici blotch survives from one season to the next on stubble. Following rain or heavy dew in late autumn and early winter, wind borne spores (ascospores) are released from fruiting bodies (perithecia) embedded in the stubble of previously infected plants. These spores can be spread over large distances (Figure 3.17).

Early ascospore infections cause blotches on the young leaves. Within these blotches a second type of fruiting body (pycnidia) are produced. Asexual spores ooze from pycnidia when the leaf surface is wet, and spores are dispersed by rain splash to other leaves where they cause new infections. This phase of disease development depends on the rain splash of spores; therefore, Septoria tritici blotch will be most severe in seasons with a wet spring. A combination of wind and rain provides the most favourable conditions for spread of this disease within crops.

Septoria Leaf Blotch Management

An integrated approach that incorporates variety selection, cultural practice, crop rotation and fungicides is the most effective way to manage Septoria tritici blotch.

Cultural Practice

Avoid planting wheat into paddocks with wheat stubble. If this is not possible, destroying stubble by grazing or cultivation will reduce the number of spores available to infect the new season's crop. A one-year rotation out of wheat is generally effective to provide a disease break. However, as the fungus may survive for over 18 months on stubble during very dry seasons a two year break is preferred.

Avoiding early sowing can help an emerging crop miss early spore release as a high number of ascospores are usually released early in the season. Where possible plant varieties with more resistance early in the program and leave the susceptible varieties until later in the program and remember that susceptible varieties planted early are at greatest risk from Septoria tritici blotch.

Variety Selection

It is important to avoid susceptible and very susceptible varieties, if possible, as they are at greatest risk of yield loss and will also build up inoculum levels across a district, placing increased pressure on moderately susceptible wheat crops. For information on the resistance status of varieties consult a current Victorian Cereal Disease Guide or the NVT website.

Fungicides

Some seed and fertliser applied fungicides can suppress early infection and should be used in areas where Septoria tritici blotch is known to occur. Where necessary, effective foliar fungicide sprays are available. However, it is important to correctly identify Septoria tritici blotch before spraying with a fungicide as nutritional disorders such as aluminium toxicity or zinc deficiency can be confused with Septoria tritici blotch.

In high risk areas, the timing of fungicides will be important to achieve adequate disease control. In early sown, susceptible varieties, a fungicide application at growth stage (GS) 31-32 may be required to suppress the disease and protect emerging leaves. Once the flag leaf has fully emerged at GS39, another fungicide application may be required to protect the upper canopy.

Fungicide Resistance

Fungicide resistance is developing in the Septoria tritici blotch pathogen in eastern Australia. Reduced sensitivity to some triazole (Group 3) fungicides was detected many years ago while resistance to strobilurins (Group 11) was detected in 2021. It is therefore important that strategies to minimise the development of fungicide resistance in the Septoria populations are implemented. For further details on fungicide resistance see Chapter 16 (Fungicides).

Biosecurity

Resistant mutations of the Septoria tritici blotch fungus have been identified in other countries, including New Zealand, the United Kingdom and mainland Europe, therefore it will be important for travellers not to accidentally introduce resistant strains of the STB fungus into Australia after returning home from overseas.

Basic biosecurity hygiene for travellers includes washing clothes and cleaning footwear before returning to Australia or leaving clothing and footwear behind if high risk areas have been visited. Remind family members, friends, employees or others travelling to also take these precautions.

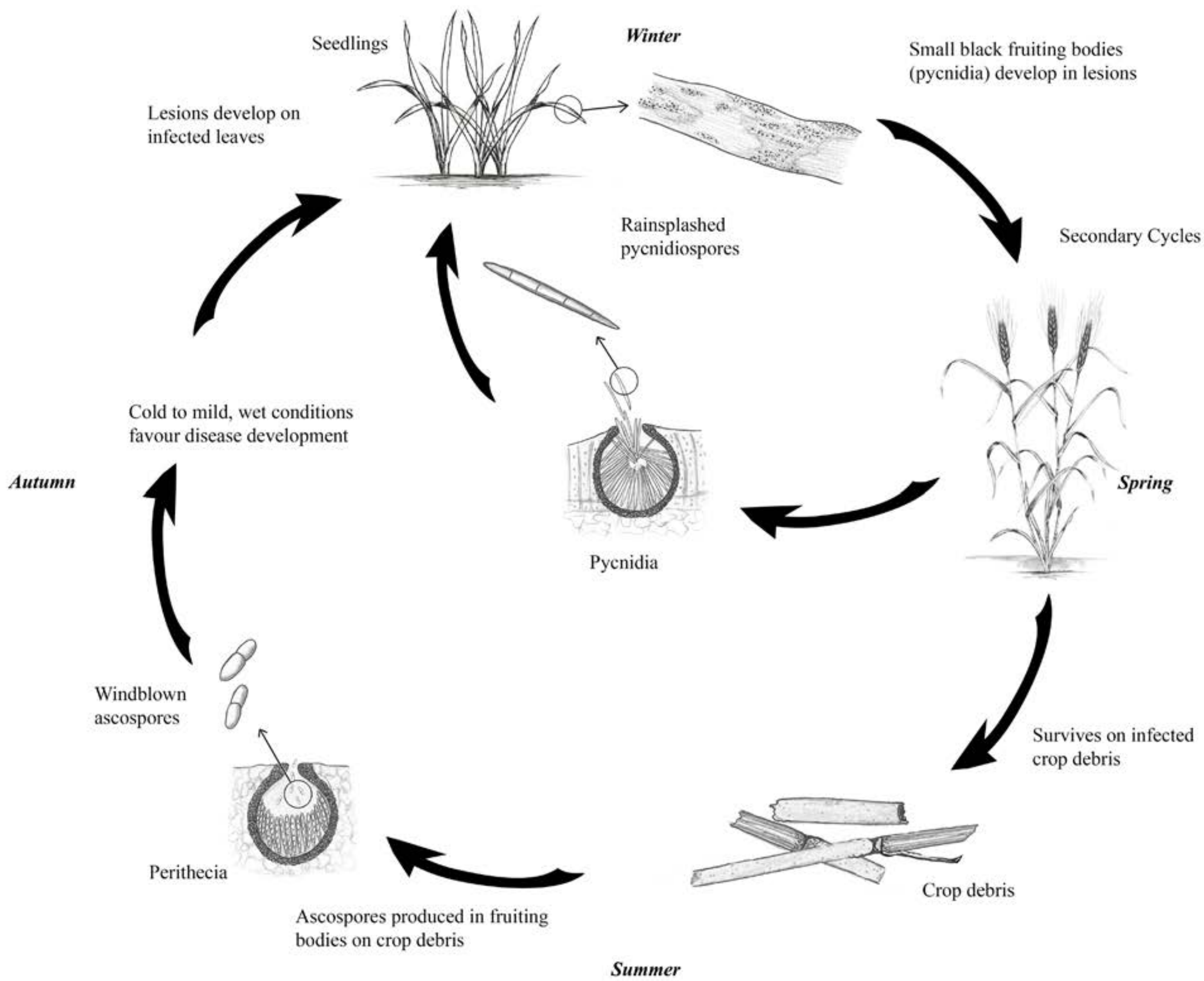


Figure 3.17. Disease cycle of septoria leaf blotch of wheat. Illustration by Kylie Fowler

POWDERY MILDEW OF WHEAT

In recent years with the increased susceptibility to Powdery mildew in the dominant wheat varieties this disease has become increasingly important. The Powdery mildew that attacks wheat (*Blumeria graminis* f. sp. *tritici*) will not attack barley and visa-versa.

The disease is most common in lush, early sown crops with adequate nitrogen nutrition. It is first observed during tillering but does not normally persist beyond ear emergence, but given suitable conditions can impact grain yield.

What to Look For

At first, small, yellow spots appear on the leaves. Several days later a white fluffy fungus can be seen in these spots (Figure 3.18).

The fungus can infect all above-ground parts of the plant, including the head. It causes yellowing and early death of leaves. Later in the season the fungus produces small black specks. These are commonly found in old infections near the base of the plant.

Disease Cycle

Each mildew infection produces masses of tiny, white spores. These are readily blown about by the wind, spreading the disease. The fungus needs a high humidity but not rain or dew to infect the plant. Development of Powdery mildew is greater at mild temperatures (15-22°C) and in lush crops.

Mildew symptoms usually appear five to seven days after infection. The fungus can multiply quickly, and crops can become heavily diseased within four to five weeks of the first signs of the disease. The disease most likely carries over from one season to the next on the stubble (Figure 3.19).

Mildew from one cereal (e.g. barley) will not infect other cereals (e.g. wheat).

Powdery Mildew of Wheat Management

Cultural

No stubble treatments or crop rotations will effectively control Powdery mildew because spores can be readily blown onto a healthy crop from diseased crops in the district.

Variety selection

There is variation in wheat varieties to their reaction to Powdery mildew. In areas prone to Powdery mildew avoid highly susceptible varieties if possible. Current varietal disease ratings for Powdery mildew can be found in a current Victorian Cereal Disease Guide or the NVT website.

Fungicides

There are both seed and foliar fungicides available for the suppression of Powdery mildew in wheat. As mildew builds up on the base of plants foliar applications before canopy closure are usually more effective as the fungicide is able to reach the target. It is for this reason that effective seed or fertiliser treatments are important for control of this disease.

Fungicide resistance

Powdery mildew is resistant to all Group 11 (QoI) fungicides in NSW, SA, Tas. and Vic. Powdery Mildew is also resistant to the Group 3 (DMI) fungicides, propiconazole and tebuconazole, in NSW and Vic.

See the details for AFREN in the further information section for up to date information.

Figure 3.18. Powdery mildew on barley. Symptoms of white fluffy fungus on leaves are similar on wheat

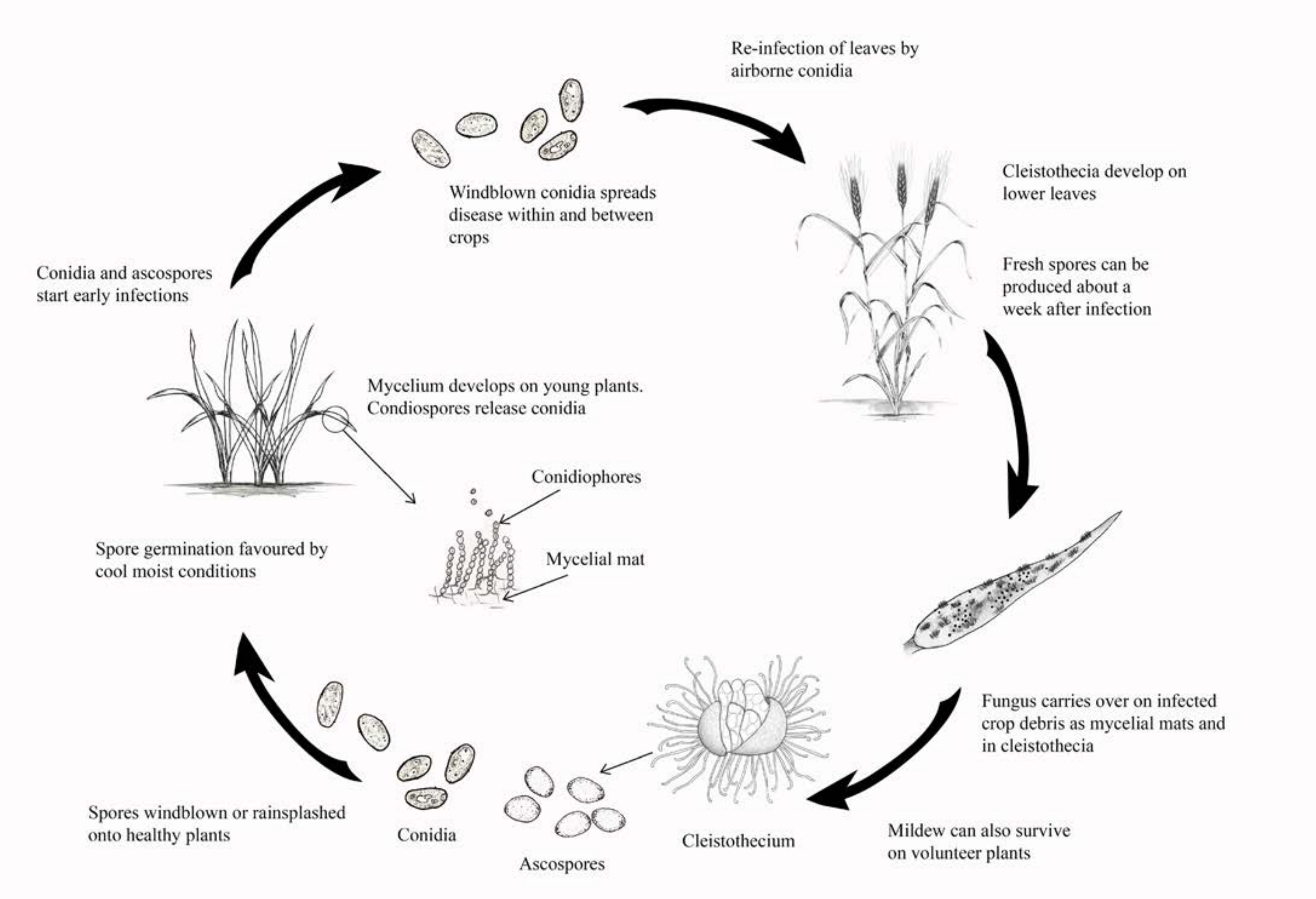


Figure 3.19. Disease cycle of Powdery mildew on cereal. Illustration by Kylie Fowler

FURTHER INFORMATION

More detailed information can be obtained from:

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/biosecurity/plant-diseases/grain-pulses-and-cereal-diseases

Victorian Cereal Disease Guide

agriculture.vic.gov.au/cereal-disease-guide

Victorian Crop Sowing Guide

grdc.com.au/NVT-Victorian-Winter-Crop-Summary

Cereal Seed Treatment Guide (SARDI)

www.pir.sa.gov.au

Other state crop summaries

grdc.com.au/resources-and-publications/all-publications/crop-variety-guides

Rust Pathotype Survey

To support the monitoring of rust isolates in Australia sent infected leaves in paper envelopes (do not use plastic wrapping or plastic lined packages) along with your contact details and, if possible, include the latitude and longitude of the sample location to:

University of Sydney
Australian Rust Survey
Reply Paid 88076
Narellan NSW 2567

Further instructions can be found at the University of Sydney cereal rust research website.

www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/cereal-rust-research/rust-reports.html

AFREN | Australian Fungicide Resistance Extension Network

afren.com.au

FOLIAR DISEASES OF BARLEY

Author: Dr Mark McLean (Agriculture Victoria)

RUSTS OF BARLEY

Overview

There are five different rusts that can infect barley. Each varies in importance depending on variety susceptivity, seasonal conditions and control strategies in place.

- **Leaf rust**, caused by *Puccinia hordei*, is common in high rainfall areas and is present in other areas during wet seasons. Losses of up to 20 per cent are possible during favourable seasons.
- **Stem rust**, caused by *Puccinia gramini*s, is uncommon but can cause severe crop losses of up to 40 per cent during wet and warm seasons.
- **Barley grass stripe rust**, *Puccinia striiformis* f. sp. *pseudo-hordei*, is very common on barley grass and can infect some susceptible varieties. However it generally does not cause loss.
- **Barley stripe rust**, caused by *Puccinia striiformis* f. sp. *hordei* is an **exotic** disease that can potentially cause severe infection and losses of up to 30 per cent.

Leaf rust occurs most years in susceptible varieties, especially in high rainfall regions. Early infections (July – August) can result in yield losses of up to 20 per cent. Stem rust is potentially the most devastating disease of the rusts and is able to cause complete crop loss in the rare event where conditions are suitable for a severe outbreak. Barley grass stripe rust is common but unlikely to cause yield loss. The exotic pathogen barley stripe rust will cause severe losses of up to 30 per cent in most varieties if it is introduced to Australia.

Figure 4.1. Star of Bethlehem

Figure 4.2. Leaf rust symptoms on barley leaf

Disease Cycle (See Wheat Rust Life Cycles)

The primary source of inoculum for leaf rust is volunteer barley plants that survive over summer. Development of leaf rust is most rapid during warm (15-20°C), moist (rain or dew) weather. Crops that have a late maturity, following a wet summer are often more severely infected.

The 'Star of Bethlehem' (*Ornithogalum umbellatum*) weed (Figure 4.1) can be a source of inoculum and is a host for the alternate, sexual stage of teleospores. The sexual cycle results in new strains that can overcome resistances. Currently the Star of Bethlehem weed occurs in South Australia with isolated occurrences through the Victorian cropping zone.

Leaf Rust: What to Look For

Pustules of leaf rust are small and circular producing a mass of orange-brown powdery spores predominantly on the upper leaf surfaces (Figure 4.2). These pustules easily rub off on a finger. Later in the season, pustules also develop on leaf sheaths. As the crop matures the pustules turn dark and produce black spores embedded in the old plant tissues. Leaf and stem rust may be confused but are distinguished by their colour and size, leaf rust being lighter coloured, smaller and rounder than stem rust.

Stem Rust: What to Look For

Pustules are large, oval to elongated and are often surrounded by a characteristic torn margin. The pustules are full of reddish, brown spores which fall away easily. They can occur on stems, leaf surfaces, the leaf sheaths and heads. As a plant matures, the pustules produce black spores that do not dislodge.

Barley Grass Stripe Rust: What to Look For

Symptoms are very similar to stripe rust in wheat. Bright yellow-orange spores form pustules that occur in stripes along the leaves.

In young leaves, the pustules tend to be scattered across the leaf. Spores rub off easily onto a finger. Barley grass stripe rust and barley stripe rust have the same symptoms. Unusually severe reactions could indicate the exotic barley stripe rust and must be reported via the Exotic Plant Pest Hotline (1800 084 881).

Figure 4.3. Stem rust symptoms on barley

Figure 4.4. Barley grass stripe rust symptoms on barley

MANAGEMENT

Variety Selection

The most effective way to control the three rusts of barley is to grow varieties with resistance. By growing resistant varieties:

- the amount of disease in a crop and neighbouring crops are reduced
- the chance of the rusts mutating, enabling them to attack previously resistant varieties is reduced
- and the resistance varieties currently available are better protected.

It is important to note that new races of barley rust can develop that overcome varieties with resistance. To select varieties with effective resistance, it is essential to consult a current Victorian Cereal Disease Guide or the NVT website.

Cultural Practices

These rusts survive predominantly on summer/autumn volunteers which provide significant inoculum loads if left unmanaged. Removing the inoculum provided by self-sown barley is very effective in reducing risk of loss. Use grazing and/or herbicides to remove green growth, especially during wet summers and aim to eliminate the green bridge prior to March for greatest benefit.

Seed Treatment

Fluxapyroxad is registered for control of barley leaf rust which can prevent early leaf rust infection. Efficacy is likely to vary between seasons and a follow up foliar fungicide application may be necessary for control later in the season.

Fungicides

There are a range of foliar applied fungicides available that will give disease suppression of leaf rust in barley. Research by Agriculture Victoria and Birchip Cropping Group has shown that the most effective suppression of leaf rust was achieved when foliar fungicides were applied early in an epidemic. Additional applications may also be required where rust pressure is sustained during a wet spring.

Seed applied fluxapyroxad and fertiliser applied fungicides are registered for control of barley leaf rust. These can prevent early leaf rust infection, however, efficacy is likely to reduce significantly as the season progresses. Continue to monitor crops during the season as a follow up application of foliar fungicide may be necessary if the epidemic persists during the spring months.

SCALD OF BARLEY

Barley scald is caused by the fungus *Rhynchosporium commune* (formerly known as *R. secalis*) and is common in all barley growing regions. Its severity varies significantly within a given crop, between crops and seasons, depending on seasonal conditions. It is most prevalent in high rainfall seasons, particularly following an early and wet season break. Grain yield losses due to scald are generally 10-20 per cent in susceptible varieties, while individual losses can be as high as 40 per cent.

What to Look For

The disease causes lesions of the leaf blades and sheaths. At first, scald appears as water-soaked, grey green lesions, which change to a straw colour with a brown margin that are ovate to irregular in shape.

In severe infections, the disease can cause complete defoliation by coalescing of the lesions.

Disease Cycle

Rhynchosporium commune (Scald) survives over summer and autumn on stubble of infected plants. Spores are dispersed from the stubble during Autumn by rain splash into the new season's crop, where they start the primary infection. Scald is usually first observed in isolated patches of a crop when plants are tillering or at early stem elongation. Further spread can be rapid during warmer conditions (15-20°C) and is caused by splash dispersal of spores. By the end of the growing season scald can be found throughout the crop with distinct hotspots. The disease is most severe in seasons of above average rainfall, particularly during the winter and spring.

Scald can also be seed-borne, can infect barley grass and survive on volunteers. These sources are less important than infected stubble but can be an inoculum source, especially during seasons with favourable climatic conditions.

Figure 4.5. Scald of barley. Early water-soaked, grey-green symptoms compared to later straw colour lesions with a distinctive brown margin

Figure 4.6. Severe scald of barley: Note the scald-like lessions can coalesce and cause complete leaf loss.

Management

Cultural Practices

Carry-over of scald inoculum can be reduced by using crop rotations that avoid consecutive barley crops and ideally a two year or more break between barley crops. This allows infected crop residue to breakdown. Grazing, burning and cultivation of stubble, volunteers and barley grass, can reduce inoculum loads but do not eliminate the disease as scald will survive on small amounts of remaining residue. Scald is also more severe in early sown crops, so avoid early sowing of susceptible varieties, especially in high rainfall areas to reduce the risk of loss caused by scald.

Variety Selection

Cultivation of resistant varieties gives the best control of scald, with the risk of grain yield and quality loss being greatly reduced by avoiding growing susceptible and very susceptible rated varieties. Unfortunately, *R. commune* is highly variable pathogenically and able to overcome resistances rapidly, meaning that many varieties are susceptible to current strains. It is important to check a current Victorian Cereal Disease Guide or the NVT website for the resistance status of varieties.

Fungicides

There are a range of fungicides available that will provide suppression of scald. Fertiliser and seed applied fungicides provide effective suppression during the seedling stages of crop development, while foliar fungicides are most effective when applied during the beginning of stem elongation (GS31) to flag leaf emergence (GS39) stages. Two applications of fungicide are generally required to minimise grain yield and quality loss where disease pressure is sustained during the season.

Application that coincide with the early stages of scald development are more effective than later applications as scald can rapidly cause damage when conditions are favourable. Crop monitoring is very important during seasons of risk of scald development.

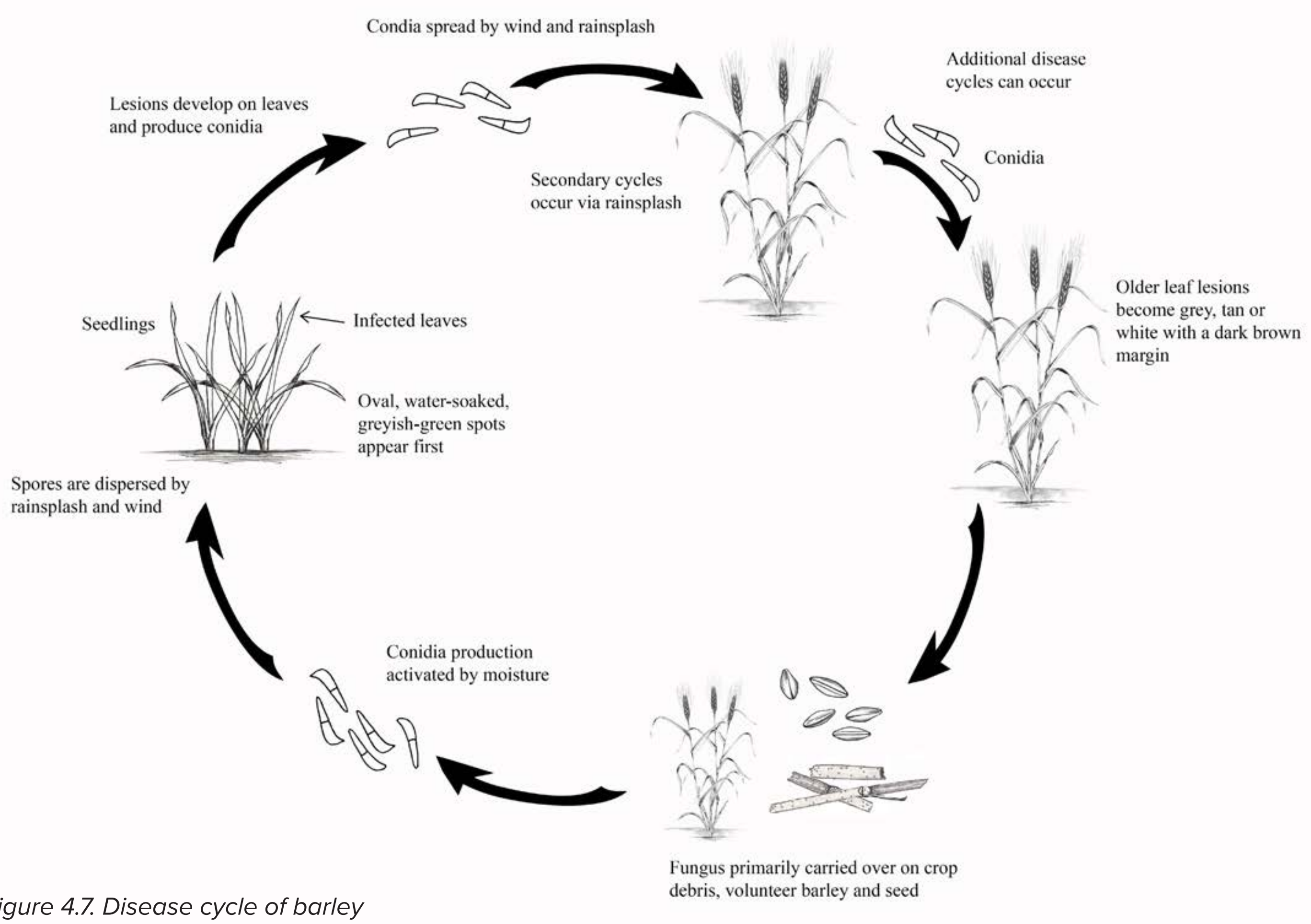


Figure 4.7. Disease cycle of barley scald. Illustration by Kylie Fowler

NET BLOTCH OF BARLEY

There are two forms of net blotch that cause loss in Australia: the spot form (SFNB) and the net form (NFNB) of net blotch. The spot form is more common in Victoria, due to the widespread cultivation of susceptible varieties. The net form is becoming more prevalent due to the increased adoption of susceptible varieties. Both diseases can be effectively managed by using a combination of varietal selection, crop rotation, and fungicides.

What to Look For

Spot Form of Net Blotch

Symptoms are most commonly found on leaves but can occasionally be found on leaf sheaths. They develop as small circular or elliptical dark brown spots surrounded by a chlorotic zone of varying width. These spots do not elongate to form net like pattern characteristic of the net form. The spots may grow in diameter to 3-6 mm.

Net Form of Net Blotch

The net form of net blotch starts as pinpoint brown lesions which elongate and produce fine, dark brown streaks along and across the leaf blades, creating a distinctive net-like pattern. Older lesions continue to elongate along leaf veins and often are surrounded by a yellow margin.

Disease Cycle

Primary inoculum of both forms of net blotch comes from infected stubble. Net blotch can survive on infected barley stubble as long as the stubble is present on the soil surface, which is generally two years after the crop is harvested. However, it can be three years in drier environments.

Ascospores are produced by pseudothecia on the stubble residues, that are spread by rain-splash or wind to infect neighbouring plants. Most of these ascospores only travel short distances within the crop. Infection requires moist conditions with temperatures of 12-25°C, and is most rapid 15-20°C.

The disease cycles for the two forms of net blotch differ in that NFNB can be carried over on seed, while the SFNB is not seedborne. Carryover of NFNB onto seed occurs when humid conditions are present at crop maturity.

Secondary infection can occur repeatedly throughout the season through conidia produced from lesions on leaves, usually within 14-20 days after primary infection. These lesions usually start on the lower leaves which then infect the upper leaves during moist conditions. Unlike the ascospores, conidia are wind dispersed and can travel considerable distances. The likelihood of infection decreases with distance from the source. As the barley plant begins to senesce, the fungus grows into the stem as a saprophyte. After harvest, it survives on the stubble and will begin producing ascospores when cool moist conditions are present.

Figure 4.8. Typical symptoms of spot form of net blotch

Figure 4.9. Typical netting symptoms of net form of net blotch

Economic Importance

The prevalence of each net blotch is dependent on the variety susceptibility. Both net blotches can cause a significant grain yield and quality losses which can lead to downgrading of grain.

Yield losses from NFNB are generally 10 and 20 per cent, but losses of more than 30 per cent have been reported in severe cases. SFNB, generally causes losses of 5-15 per cent but in severe outbreaks can exceed 20 per cent. In general, the flag to Flag-2 leaves must be infected for yield loss to occur.

Management

Both SFNB and NFNB can be effectively controlled with an integrated strategy incorporating varietal selection, crop rotation, seed treatment and crop monitoring with a view to fungicide applications if required.

Variety Selection

Avoiding growing Susceptible (S) and Very Susceptible (VS) varieties and growing a variety with a rating of Moderately Susceptible (MS) or better significantly reduces the likelihood of grain yield and quality loss. Consult a current Victorian Cereal Disease Guide or the NVT website when selecting varieties.

Paddock Selection

Avoid growing barley in the same paddock in successive years as most inoculum survives in stubble. At least two seasons of break crops are required to reduce stubble and inoculum loads sufficiently to reduce risk. Disease levels will be higher in districts where barley crops are grown in close rotation.

Figure 4.10. Pyrenophora teres *a) stubble with pseudothecia b) ascospore c) conidia*

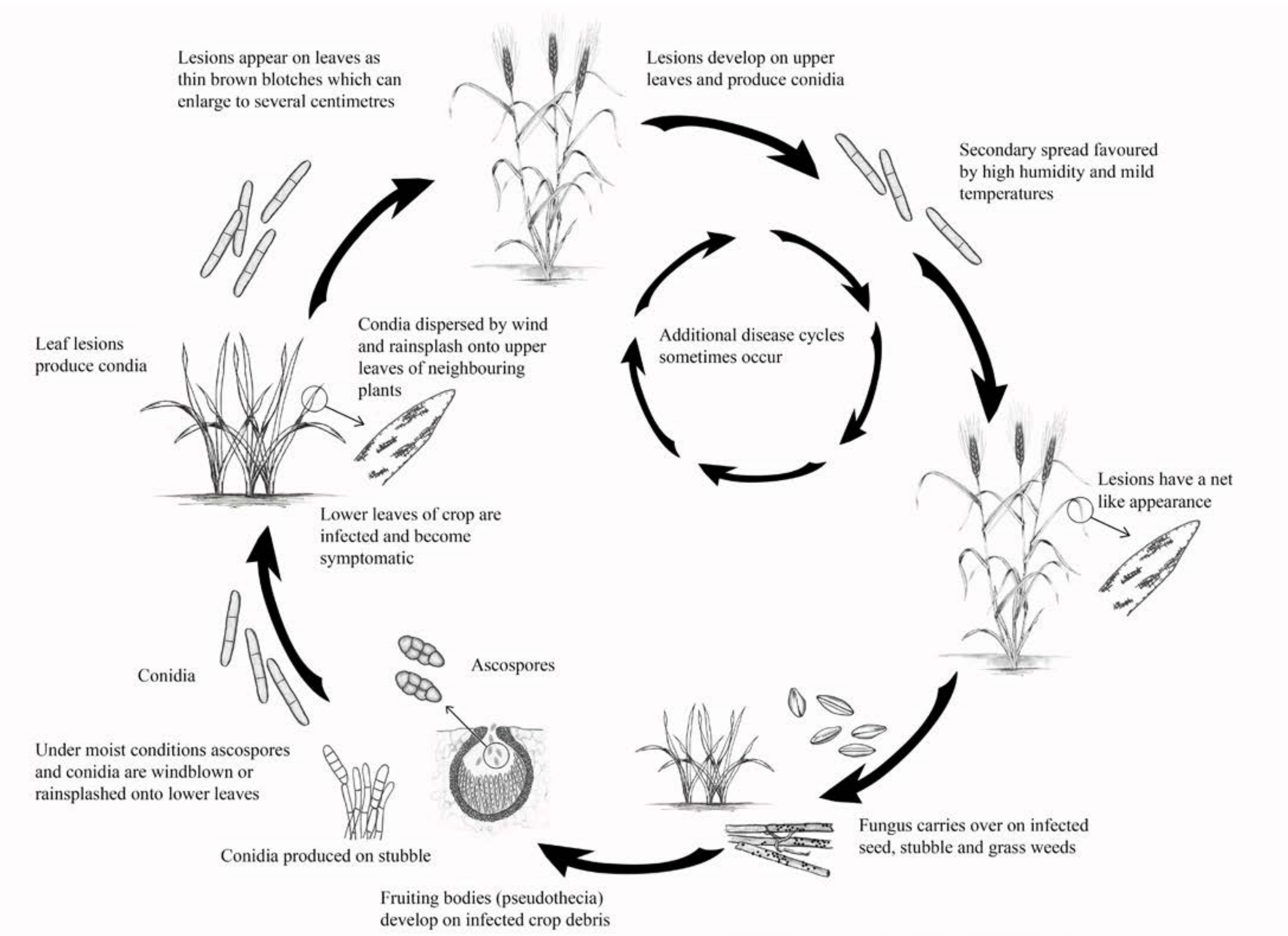


Figure 4.11. Disease cycle of net form of net blotch of barley. Illustration by Kylie Fowler

Seed Treatment

Seed treatments are registered for the net blotches. Seed treatments containing the active ingredient thiram can reduce NFNB severity in seedlings, while treatments containing the active ingredients difenoconazole + metalaxyl can reduce the carry-over of seed-borne NFNB. Fluxapyroxad is available for control of both net blotches in barley and is effective during the emergence and tillering stages of crop development and can provide control into the stem elongation stages. Ensure that other fungicides are used in rotation with fluxapyroxad as it has a SDHI mode of action which has known occurences of resistance developing in the pathogen, particularly in the net form of net blotch.

Seed treatments are most effective when combined with an application of foliar fungicide with a different mode of action during the flag emergence growth stages of crop development.

Sowing

Early sowing favours the development of the net blotches and can increases the potential for loss. Have a proactive approach to disease management in early sown crops, by applying up-front fungicides if possible and monitor with a view to application of foliar fungicides if needed during the season. Sowing later to avoid net blotch should be weighed up against other agronomic factors.

Foliar Fungicides

Foliar fungicide products are registered for suppression of net blotches. Monitor barley crops and it is recommended to apply a foliar fungicide when the percentage of leaf area affected by net blotches is greater than 10 per cent. In general, yield improvements from fungicide application are most likely where the disease is prevalent, and grain yield potential yield exceeds three t/ha.

For best suppression, foliar fungicides should be applied during early stem elongation (GS31) and flag leaf emergence (GS39). Application at late tillering (Z25) has also been shown to be effective in the shorter season Mallee environment. A single application of foliar fungicide may be insufficient to eliminate grain yield and quality loss where seasonal conditions favour net blotch development and a two application strategy may be warranted.

Application of foliar fungicide can be effective during the head emergence (GS49-59) growth stages but will provide less benefit for SFNB than NFNB.

Check the product label to ensure the fungicide is effective on the form of net blotch you have, and also, check withholding periods.

Foliar fungicides are less likely to improve grain yield in moderately susceptible or better rated varieties, except during exceptionally favourable, high yielding seasons and are therefore unlikely to be economical to apply.

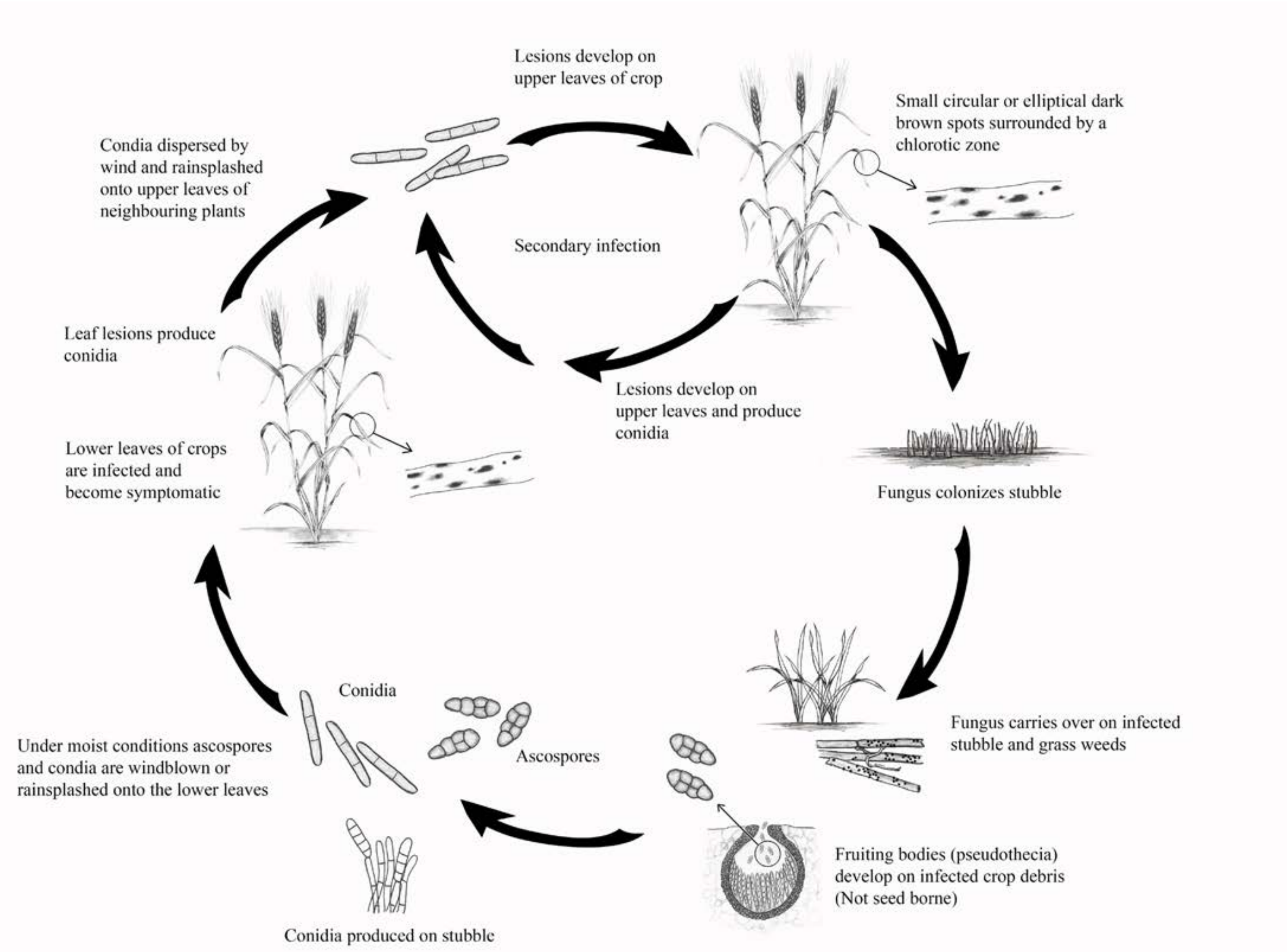


Figure 4.12. Disease cycle of spot form of net blotch of barley. Illustration by Kylie Fowler

Figure 4.13. Powdery mildew of barley

POWDERY MILDEW OF BARLEY

Powdery mildew is caused by the fungus *Blumeria graminis* f. sp. *hordei* and is most common in early sown crops with good canopy cover and good nitrogen nutrition. Symptoms are usually first observed during tillering, but the disease does not normally persist beyond ear emergence. Losses are typically minimal in Victoria but can be as much as 25 per cent in heavily-infected crops, which has been observed in South and Western Australia.

What to Look For

At first, small, yellow spots appear on the leaves. Several days later a white fluffy fungus can be seen in these spots. The fungus can infect all above-ground parts of the plant including the head. It causes yellowing and early death of leaves. Later in the season the fungus produces small black specks. These are commonly found in old infections near the base of the plant.

Disease Cycle

Powdery mildew is an obligate parasite that infects living barley plants. Infection produces masses of tiny, white spores which are spread when blown by the wind. Infection occurs when there is high humidity from dew and temperatures between 15-25°C. Mildew symptoms usually appear five to seven days after infection. The fungus can multiply quickly, and crops can become heavily diseased within four to five weeks of the first signs of the disease. The disease carries over from one season to the next on volunteers and grasses. Mildews are host specific and, therefore, mildew from barley will not infect wheat.

Management

Cultural

Remove volunteer barley plants by grazing and/or herbicides to reduce inoculum loads. Crop rotations are not an effective control of powdery mildew as spores can be readily blown onto a healthy crop from diseased crops in the district.

Variety Selection

Barley varieties vary in their susceptibility to powdery mildew so consult a current Victorian Cereal Disease Guide or the NVT website to determine risk.

Fungicides

Some seed treatment fungicides will suppress powdery mildew for 6-8 weeks following sowing. This form of control is recommended in barley crops that are sown early and in areas prone to powdery mildew. Foliar fungicides are available for suppression of powdery mildew and are best applied before the disease has infected 5 per cent of leaf area of the lowest green leaves. There is reduced sensitivity of Powdery Mildew to some triazole fungicides in Western Australia resulting in foliar fungicide application being ineffective. Crops in eastern Australia should be monitored for signs of reduced sensitivity by powdery mildew to fungicides and samples submitted to Agriculture Victoria for testing.

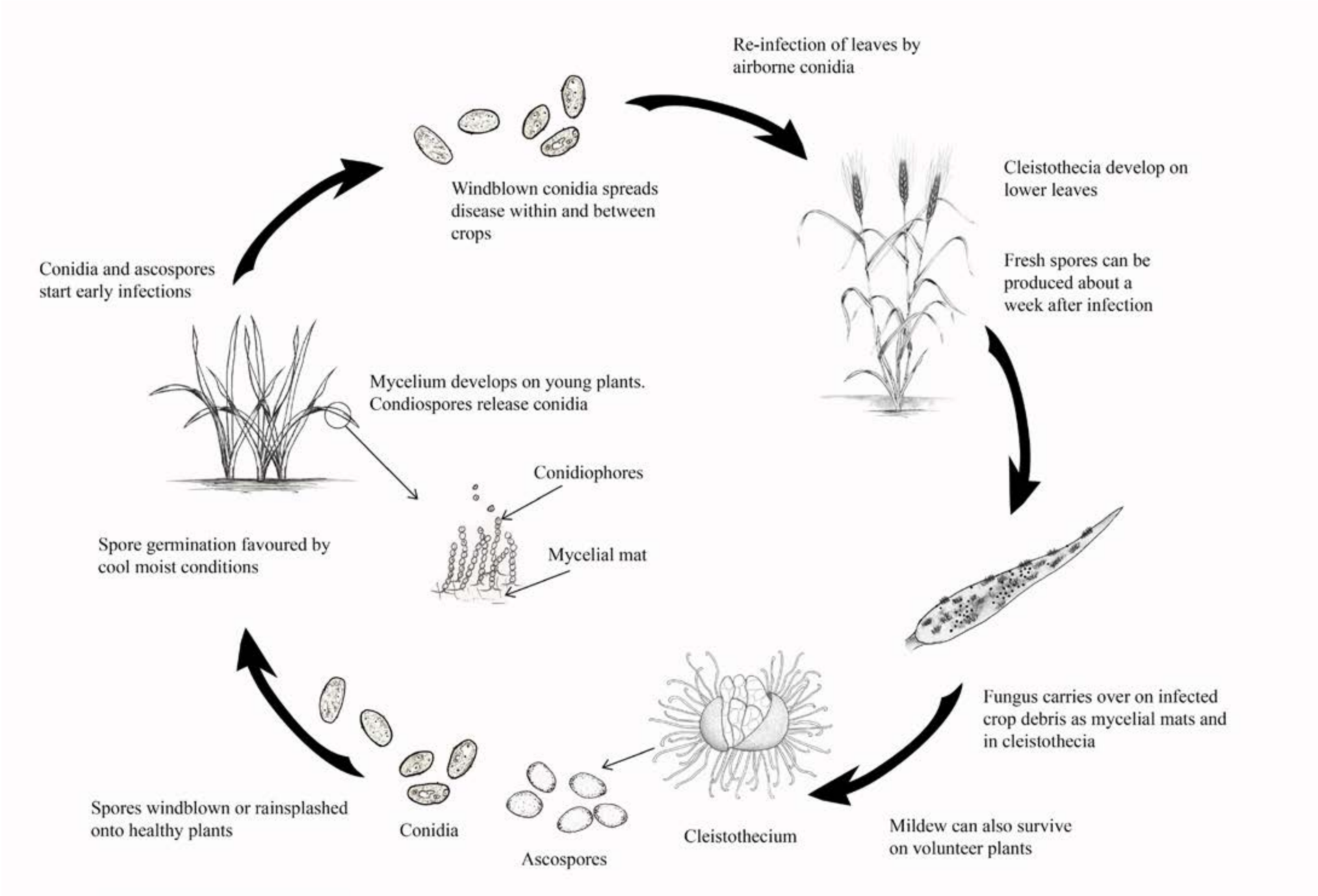


Figure 4.14. Disease cycle of powdery mildew on cereals. Illustration by Kylie Fowler

FURTHER INFORMATION

More detailed information can be obtained from:

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Cereal Disease Guide

agriculture.vic.gov.au/cereal-disease-guide

Victorian Crop Sowing Guide

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www.pir.sa.gov.au

Other state crop summaries

grdc.com.au/resources-and-publications/all- publications/crop-variety-guides

NVT website

NVT (nvt.grdc.com.au)

Cereal rust reports

Australian Cereal Rust Survey - Faculty of Science (sydney.edu.au)

Rust Pathotype Survey

To support the monitoring of rust isolates in Australia sent infected leaves in paper envelopes (do not use plastic wrapping or plastic lined packages) along with your contact details and, if possible, include the latitude and longitude of the sample location to:

University of Sydney Australian
Rust Survey
Reply Paid 88076
Narellan NSW 2567

Further instructions can be found at Australian Cereal Rust Survey - Faculty of Science (sydney.edu.au)

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FOLIAR DISEASES OF OATS

Authors: Dr Hari Dadu (Agriculture Victoria) and Dr Mark McLean (Agriculture Victoria)

INTRODUCTION

Foliar diseases can significantly reduce hay and milling oat yield and quality. The major foliar diseases of oats in Victoria include Red leather leaf, Bacterial blight, Septoria blotch, Crown (Leaf) rust and Stem rust. Recent surveillance activities in Victoria (2018-2021) identified Red leather leaf and Bacterial blight as the most common foliar diseases with other diseases such as Stem rust, Crown rust and Septoria blotch observed at low incidence.

Crops grown in the high and medium rainfall zones generally had higher disease severity compared to crops grown in low rainfall zones. In this chapter we describe the identification and management of these important foliar diseases affecting oats.

Table 5.1. Overview of symptoms and the optimal temperature range for oat foliar diseases

DISEASE		PATHOGEN	SYMPTOMS	OPTIMAL TEMPERATURE RANGE FOR INFECTION (°C)
Red leather leaf		*Neospermospora avenae*	Leathery textured reddish brown irregular shaped lesions on leaves	5-16
Bacterial blight	Stripe blight	*Pseudomonas syringae* pv. *striafaciens*	Reddish-brown stripes with yellow and red margins on leaves	Unknown
	Halo blight	*Pseudomonas syringae* pv. *coronafaciens*	Yellow-brown oval shaped water-soaked spots with yellow-green halo on leaves	
Crown rust (leaf rust)		*Puccinia coronata* var. *avenae*	Small round to oblong, orange to yellow-coloured pustules on leaves, leaf sheaths and heads	15-22
Stem rust		*Puccinia graminis* var. *avenae*	Reddish-brown, powdery, oblong pustules with a characteristic torn margin on both sides of the leaves, on the stems and the glumes	18-30

RED LEATHER LEAF OF OAT

Red leather leaf (RLL) is favoured by cool and wet seasonal conditions and was found in at least 80 per cent of oat crops in the medium and high rainfall zones of Victoria during 2019 and 2020. This makes it the most prominent foliar disease of oats in south-eastern Australia. Red leather leaf was uncommon in low rainfall zones and generally at levels unlikely to cause losses.

What to look for

Initial infection appears as small, pale blue coloured lesions with a red/red-brown edge (Figure 5.1), typically during the tillering stages. During the stem elongation to head emergence stages, symptoms appear as red, irregular shaped lesions, which spread across leaves. Later in the season, affected leaves take on a 'leathery' appearance which turn a red, brown colour and may be slightly rolled (Figure 5.1).

Disease Cycle

Red leather leaf (RLL) is caused by the fungus *Neospermospora avenae*. It is a stubble and seed borne disease, but its survival and mode of infection is not well understood. Primary infection is most likely from mycelium on seed and spores from stubble during cool (5–16°C) wet weather. Symptoms are first observed during tillering and stem elongation stages. Secondary infection of the upper canopy comes from wind and splash dispersed spores during wet weather.

Economic Importance

Red leather leaf has been found to cause 5–20 per cent (0.3–1.1 t/ha) grain yield loss in susceptible milling varieties and significant reductions to grain plumpness (screenings) and weight in the medium and high rainfall zones. In hay crops, Red leather leaf has been found to significantly reduce plant biomass, height and stem thickness. Losses of 10-22 per cent (0.8-3.2 t/ha) were common in Susceptible (S) and Susceptible to Very Susceptible (SVS) rated varieties. Less frequent and severe losses were recorded for Moderately Susceptible (MS) or better rated varieties. Losses are most likely during seasons with wet conditions during winter and early spring as this favours disease development.

Management

Cultural Practices

Infected seed and stubble are the sources of primary infection for Red leather leaf. Avoid sowing oats into oat stubble from the previous two seasons by allowing 2–3 years before re-sowing oats into the same paddock to allow the inoculum to breakdown.

Resistant Varieties

Growing Moderately Susceptible (MS) or better rated varieties will significantly reduce risk of loss. Susceptible (S) or Susceptible to Very Susceptible (SVS) rated varieties frequently have grain/hay yield and quality loss during seasons favourable for Red leather leaf. See a current Cereal Disease Guide or the NVT website for up to date ratings.

Fungicides

Foliar fungicides have been found to provide suppression of Red leather leaf, but may not provide full control. Timing of foliar fungicide application is very important with experiments conducted in the high and medium rainfall zones having shown that the best timing was mid-tillering (Z25) to stem elongation (Z31). This is because application coincides with early disease development.

It is important to follow labels rate for oats and rotate fungicides with different modes of action to minimize the opportunity for fungicide resistance developing. See Chapter 16, Fungicides, for further information about fungicide resistance.

Figure 5.1. Characteristic symptoms of Red leather leaf (RLL) in oats; pale blue lesions with a red/red-brown edge at early stages (top) and leathery appearance later in the season (bottom) (Photos: Mark McLean — Agriculture Victoria)

BACTERIAL BLIGHT OF OAT

Stripe and Halo blight are the two bacterial diseases commonly found infecting oat crops in Victoria. Surveys found Bacterial blight in 55 per cent of oat crops in Victoria, with higher incidence levels in higher rainfall zones. However, the severity was low and unlikely to cause grain/hay yield losses.

What to look for

Symptoms of stripe and Halo blight appear similar during early infection stages. Initially both produce water-soaked spots on oat leaves, but these differ as they mature. Symptoms of Stripe blight lengthen and form red-brown stripes with yellow and red margins. The lesions often merge and form irregular necrotic blotches causing leaves to senesce prematurely (Figure 5.2). Halo blight produces a yellow-green halo around the yellow-brown oval shaped water-soaked spots. These spots later grow and merge with lesions causing large irregular necrotic blotches. Severe infections often lead to premature senescence of leaves (Figure 5.3).

Disease Cycle

There is limited information about the epidemiology of both stripe (caused by *Pseudomonas syringae* pv. *striafaciens*) and halo (caused by *Pseudomonas syringae* pv. *coronafaciens*) blights in Australia. It is understood that the bacteria survive between seasons on seed and stubble, while rain splash distributes bacteria amongst surrounding plants. Bacterial infections usually coincide with mid-tillering and affect all growth stages thereafter.

Economic Importance

The impact of these diseases on oat hay and grain yield is yet to be determined in Australia. Recent surveys in Victoria have indicated that Bacterial blight is the second most prevalent disease of oats following RLL. Although low incidence levels are present in most of the infected paddocks, there is potential for losses to susceptible varieties during favourable seasons.

Management

Cultural Practices

Infected seed and stubble are the primary sources for bacterial diseases. Avoid sowing into oat stubble to reduce the risk of Bacterial blight. Crop rotations with other crops that are less susceptible to bacteria should be considered.

Resistant Varieties

Growing Moderately Susceptible (MS) or better rated varieties will reduce risk of loss. Susceptible (S) to Very Susceptible (SVS) rated varieties may incur losses during seasons favourable. See a current Cereal Disease Guide or the NVT website for up-to-date ratings.

Chemical control

There are no known chemical control options for Bacterial blights. Being a bacteria, it is not controlled by fungicides.

Figure 5.2. Characteristic symptoms of Stripe blight in Oats (Photo: Mark McLean — Agriculture Victoria)

Figure 5.3. Gradual progression of Halo blight symptoms in Oats (Photo: Hari Dadu — Agriculture Victoria)

CROWN RUST OF OAT

Oat Crown rust is caused by *Puccinia coronata* var. *avenae* and is also known as Leaf rust. The word 'crown' refers to the shape of the spore produced by the fungus but not the description of the symptoms. Oat Crown rust is related to wheat and barley leaf rust but is caused by a different species which does not infect either wheat or barley. Similarly, neither wheat nor barley rusts cause infection in oats. Oat Crown rust, however, is a potentially damaging disease and can reduce both grain and hay yields. Susceptible varieties are more vulnerable to Crown rust and severe losses can be expected.

What to look for

Crown rust produces small round to oblong, orange to yellow pustules on leaves but also on leaf sheath and heads (Figure 5.4). These pustules when disrupted release powdery masses of spores which infect new plants. The pustule areas may turn black with age.

Disease Cycle

Rust requires live plants to grow and reproduce and cannot be carried over to the next season on seed, stubble or in soil. Crown rust survives on volunteer oats and/or wild oats that grow following summer rains (Figure 5.5). Plants heavily infected with the rusts become a source of infection for the new season's oat crop. The epidemic risk is higher during where there is average or greater rainfall during the spring months as optimum temperatures for rust infection are 15-22°C.

Figure 5.4. Crown rust in Oats (Photo: Kylie Chambers — DPIRD)

Economic Importance

Oat Crown rust can be a very damaging disease that reduces grain yield by up to 20 per cent and reduce grain quality. Losses to biomass and feed quality have also been reported in forage crops.

Management

Cultural Practices

Green bridge management is important during summer and autumn for rust control. Heavy grazing or herbicide application to remove volunteer and wild oats reduces rust inoculum carryover to the next season.

Resistant Varieties

The most effective way to control Crown rust is to grow resistant varieties and avoid sowing susceptible to very susceptible varieties. Resistant varieties also reduce the chance of new mutations and occurrence of new pathotypes by minimising the levels of rust in crops. Keep up to date with varieties' ratings for Crown rust with a current Cereal Disease Guide or the NVT website.

Crown rust can develop new pathotypes which can change a variety's resistance reaction. Current pathotypes are monitored every season to ensure that resistance ratings are up to date. The Australian Cereal Rust Control Program, based at the University of Sydney along with the Pests and Diseases team at CSIRO, Canberra, conducts annual monitoring of Crown rust pathotypes present in Australia, supported by GRDC. The information on the pathotypes is crucial in determining how varieties will perform against the dominant rusts present in Australia. For details on how to submit Crown rust samples for pathotyping and to view pathotyping results see the "Further Information" section at the end of this chapter.

Fungicides

Foliar fungicides are available for the control of Crown rust in oats. The best time to apply foliar fungicides is at the first sign of the rust in the crop. Rust epidemics can develop rapidly, so monitoring crops for traces of rust and application of fungicide immediately after detection is recommended. If the rust severity is high, then there may be a need for two fungicide applications. Late rust epidemics after panicle emergence are less likely to cause a significant yield loss and generally do not benefit from fungicide application.

It is important that growers follow all label directions including rates, crop growth stages and withholding periods to grazing, cutting for forage/hay and harvest to ensure that maximum residue limits are not exceeded in destination markets.

DO NOT apply more than 2 applications of any product(s) from the same mode of action group in any one season. If additional applications are required during periods of high disease pressure, then growers need to switch to alternative products with differing modes of action. To reduce the risk of fungicide resistance development. See Chapter 16, Fungicides, for further information about fungicide resistance.

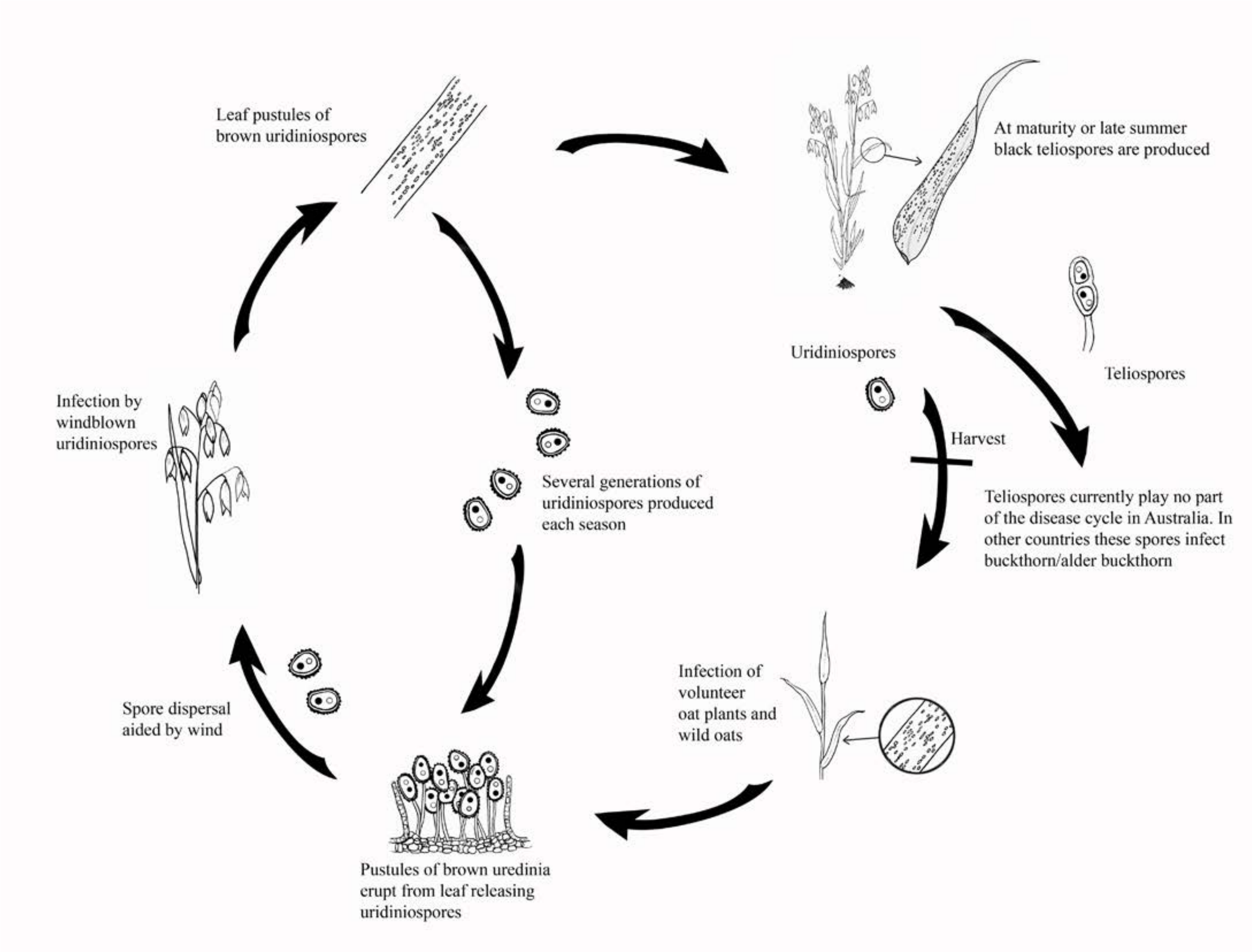


Figure 5.5. Disease cycle of Crown rust on oats. Illustration by Kylie Fowler

Figure 5.6. Stem rust in Oats (Photo: Kylie Chambers — DPIRD)

STEM RUST OF OAT

Stem rust in oats is caused by fungus *Puccinia graminis* var. *avenae*. Stem rust is found across oat growing regions of Victoria. It can be a damaging disease that can cause significant yield losses in susceptible cultivars.

What to look for

Stem rust can infect leaves, leaf sheaths, stems, and panicles. Stem rust produces reddish-brown, powdery, oblong pustules with a characteristic torn margin that can occur on both sides of the leaves, on the stems and the glumes. Stem rust spores are much darker in colour than Crown rust spores, which are light brown and don't have torn margins (Figure 5.6).

Disease Cycle

Like other rusts of cereals, Stem rust requires living hosts to grow and reproduce. It survives on volunteer and/or wild oats during summer and builds the inoculum for the next season. Spores are readily dispersed by wind and travel long distances. Stem rust usually develops at higher temperatures than Crown rust at temperatures of 18 to 30°C, and is therefore more problematic for in longer season, high rainfall environments. The latent period of Stem rust is relatively short and can produce new spores within 7-10 days following infection.

Economic Importance

Stem rust can cause yield losses of 50 per cent in both hay and milling oat crops and can cause total crop failure when susceptible cultivars grown under favorable conditions.

Management

Cultural Control

Control measures for Stem rust are very similar to Crown rust. Pre-season management including control of volunteers and wild oats is critical for reducing inoculum levels and carry over to the next season. Stem rust requires slightly warmer temperatures and develops late in the season meaning that most crops escape serious infection.

Variety Resistance

Cultivation of resistant cultivars is highly recommended where crops are at risk of losses. See a current Cereal Disease Guide for up-to-date ratings. Where susceptible varieties are at risk, fungicide application soon after the detection of rust pustules will reduce losses in susceptible varieties.

Stem rust can develop new pathotypes which can change a variety's reaction. Current pathotypes are monitored every season to ensure that resistance ratings are up to date.
The Australian Cereal Rust Control Program, based at the University of Sydney and supported by GRDC, conducts annual monitoring of Stem rust pathotypes present in Australia. The information on the pathotypes is crucial in determining how varieties will perform to the dominant rusts present in Australia. For details on how to submit Stem rust samples for pathotyping and to view pathotyping results see the "Further Information" section at the end of this chapter.

Fungicides

It is important that growers follow all label directions including rates, crop growth stages and withholding periods to grazing, cutting for forage/hay and harvest to ensure that maximum residue limits are not exceeded in destination markets.

DO NOT apply more than 2 applications of any product(s) from the same mode of action group in any one season. If additional applications are required during periods of high disease pressure, then growers need to switch to alternative products with differing modes of action. To reduce the risk of fungicide resistance development. See Chapter 16, Fungicides, for further information about fungicide resistance.

FURTHER INFORMATION

More detailed information can be obtained from;

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Cereal Disease Guide

agriculture.vic.gov.au/cereal-disease-guide

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Cereal Seed Treatment Guide (SARDI)

www.pir.sa.gov.au

Other state crop summaries

grdc.com.au/resources-and-publications/all- publications/crop-variety-guides

NVT website

NVT (nvt.grdc.com.au)

Cereal rust reports

Australian Cereal Rust Survey - Faculty of Science (sydney.edu.au)

Rust Pathotype Survey

To support the monitoring of rust isolates in Australia sent infected leaves in paper envelopes (do not use plastic wrapping or plastic lined packages) along with your contact details and, if possible, include the latitude and longitude of the sample location to:

University of Sydney Australian
Rust Survey
Reply Paid 88076
Narellan NSW 2567

Further instructions can be found at Australian Cereal Rust Survey - Faculty of Science (sydney.edu.au)

Oat Crown Rust Survey - CSIRO

CSIRO are looking for samples of oat Crown rust to support their research. For further information visit www.csiro.au/en/research/plants/Pathogens-Pests-Weeds/Rusts-and-mildews/Rust-sample-collection-guidelines

AFREN | Australian Fungicide Resistance Extension Network

afren.com.au

BUNTS AND SMUTS OF CEREALS

Authors: Dr Grant Hollaway (Agriculture Victoria), Dr Mark McLean (Agriculture Victoria), and Luise Fanning (Agriculture Victoria)

INTRODUCTION

Bunt and smut fungi are potentially devastating diseases of cereals. The zero or very low tolerance levels at receival centres makes infected grain unsaleable or only saleable as low value stock feed. Fortunately, the regular use of seed applied fungicides (pickles) can cheaply and effectively control these diseases.

All cereals are susceptible to several smut and bunt fungi. In most cases, each of the cereal smuts are caused by a distinct species specific to each crop; that is loose smut of wheat is different to loose smut of barley.

Grain receival standards

There are strict receival standards for grain in relation to bunts and smuts. For loose smut the tolerance is a maximum of 3 pieces per half litre of grain for wheat and 0.1 g per half litre of grain for barley. For all other types of bunts and smuts there is a nil tolerance (Table 6.1).

Seed Treatments

Fungicide seed treatments provide effective control of bunts and smuts by preventing seed-borne infection. In order to achieve effective control, seed treatments need to be applied to seed every year and good coverage must be achieved. If a seed lot is already infected, new clean seed should be sourced. Some seed treatments, particularly on poor seed, can cause issues with coleoptile length resulting in poor emergence. Always read the label.

Basic seed treatments provide a cheap means of controlling bunts and smuts. There are also a range of seed treatments that are dearer but provide control of some foliar and/or root diseases. These treatments may be useful in an integrated disease control program. SARDI produces an annual cereal seed treatment guide which provides comparison tables for actives and what diseases they effectively control.

Table 6.1. Bunt and smut grain receival standards in Australia for 2021/22(www.graintrade.org.au/commodity_standards)

WHEAT	TOLERANCE
Smut (Tilletiea caries)	NIL
Loose smut	Max 3 pieces per half litre
WHEAT	**TOLERANCE**
Loose smut	0.1 g of all pieces per half litre
Cereal smut (Ball and gall smut, other smut species)	NIL

BUNT OF WHEAT

Bunt of wheat, also known as 'covered smut', 'ball smut' or 'stinking smut' is a fungal disease caused by *Tilletia laevis* (formerly *T. foetida*) and/or *T. tritici* (formerly *T. caries*).

In general, this disease is well controlled through the widespread use of seed treatments. Despite this, bunt outbreaks are reported most years, and are often in crops where seed treatments have not been used, were not used every year or where inadequate coverage of the seed occurred.

Receival Standards

Grain Trade Australia's commodity standards have a nil tolerance for bunt in all grades of wheat. See Table 6.1.

Figure 6.1. Healthy and bunt infected wheat grain (Photo: Grant Hollaway — Agriculture Victoria)

What to Look For

A bunt infection of wheat is usually first noticed at harvest because of the strong putrid fishy smell emitted from the grain. Closer examination of seed will reveal bunt balls, which are grains of wheat that have been replaced by a mass of stinking bunt spores (Figure 6.1). It is these bunt balls that break during harvest and seed movement that enable the disease to spread through a seed lot and infect the seed that will be sown next season.

Even though bunt infected plants may be shorter than healthy ones, it is difficult to identify a bunt infected crop before crop maturity. At maturity, bunted heads are darker in colour and have splayed glumes because of the large black bunt balls present within the glume (Figure 6.2).

Disease Cycle

Bunt balls that break during harvest contaminate seed and soil. When infested seeds are sown bunt spores germinate and the fungus infects the growing point of the wheat seedling. Following infection of the young seedling the fungus grows within the plant, generally without producing symptoms until the head develops. When new seed begins to develop in the head, the fungus replaces the tissues of the developing seed with its own spores.

Bunt can survive in soil for at least a year and for many years on seed. Bunt spores prefer moist and cool conditions (5-15°C) for germination. Therefore, early sowing into warmer soils can help reduce the level of crop infection (Figure 6.3).

Management

Fungicidal seed treatments are extremely effective in controlling bunt. However, seed treatments need to be applied every year with good coverage of grain to prevent infection.

Following a bunt infection clean seed should be obtained. All machinery that handled infected grain should be thoroughly cleaned and wheat should not be sown back into an infected paddock for several years.

Figure 6.2. Splayed glumes of wheat ear infected with common bunt (Photo: Grant Hollaway — Agriculture Victoria)

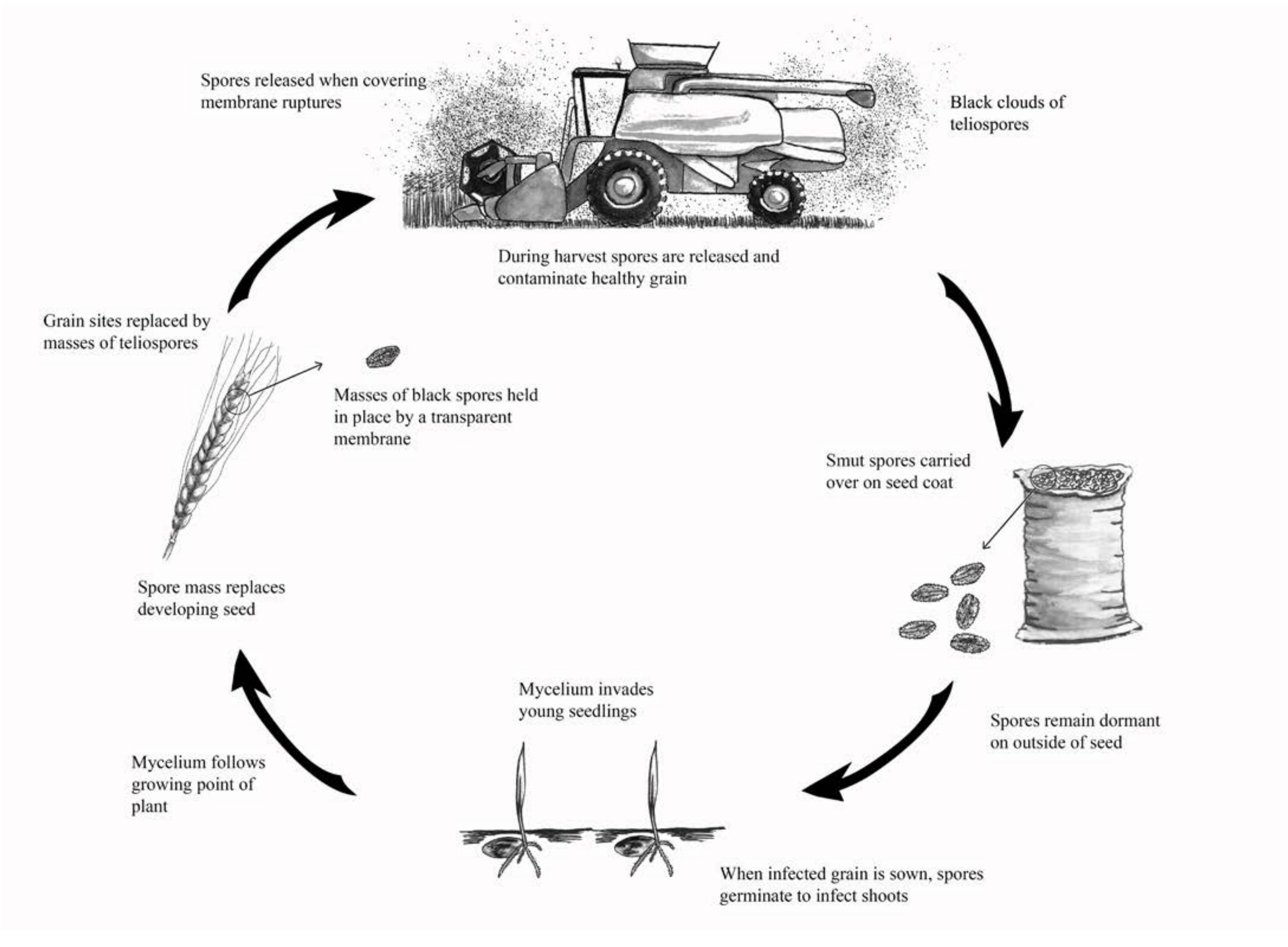


Figure 6.3. Disease cycle of covered smut (bunt/stinking smut) in cereals. Illustration by Kylie Fowler

LOOSE SMUT OF WHEAT

Loose smut of wheat is caused by the fungus *Ustilago tritici* (formerly *U. nuda*). In Victoria, this disease is rarely seen because the regular use of seed treatments provides effective control of this disease.

Figure 6.4. Wheat ears infected with loose smut. The ear on the right indicates all that remains after the loose smut has blown free (Agriculture Victoria)

Receival Standards

Grain Trade Australia's commodity standards allow a maximum of 3 pieces of loose smut infected ear per half litre for all grades. See Table 6.1.

What to Look For

Loose smut symptoms do not become apparent until head emergence. At this time heads of infected plants emerge earlier, have a darker colour and are slightly taller than the heads of healthy plants. On infected heads the florets are full of a mass of black spores. These spores are initially held by a thin membrane, which soon ruptures releasing spores. Eventually all that remains of the head is the bare stalk (Figure 6.4).

Disease Cycle

Heads of infected plants emerge earlier than those of uninfected plants. The spores released from the infected heads land on the later emerging florets of the healthy plants and infect the developing seed. Infection during flowering is favoured by frequent rain showers, high humidity and temperatures of between 16-22°C.

Infected seed shows no visible signs of infection as the fungus survives as dormant hyphae in the embryo. When infected seed germinates the fungus grows asymptomatically within the plant. As the plant elongates the fungus proliferates within the developing spike and spores develop replacing the healthy grain. Eventually the wheat head is a mass of spores, ready to infect healthy plants (Figure 6.5).

Management

Using fungicidal seed treatments every year will effectively control this disease. Good seed coverage of product is essential. Following a loose smut outbreak new clean seed should be sourced.

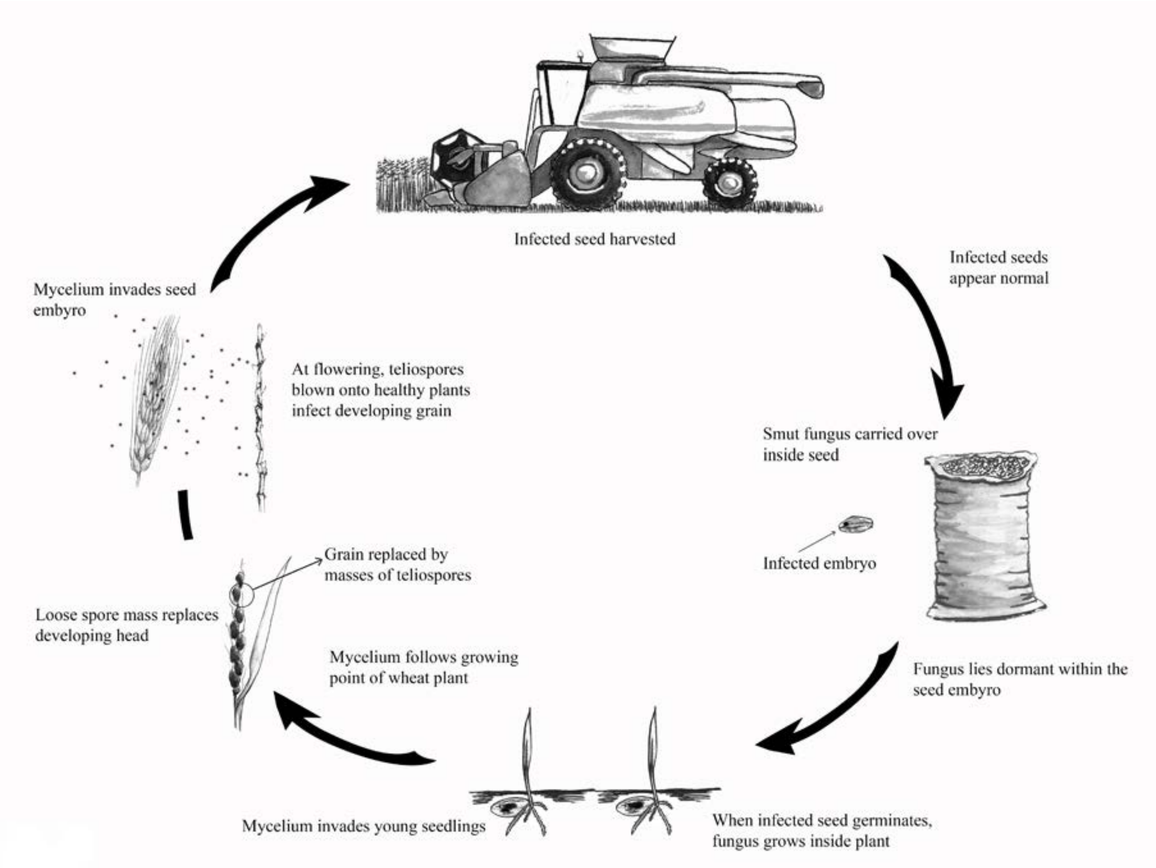


Figure 6.5. Disease cycle of loose smut in cereals. Illustration by Kylie Fowler

FLAG SMUT OF WHEAT

Historically flag smut, caused by the fungus *Usrocystis agropyri*, was an important disease of wheat in Victoria. However, in recent years this disease has been controlled with the use of resistant varieties and treatment of seed with fungicides. Losses from flag smut of wheat, when the disease occurs, are generally in the range of 5 to 20 per cent, however complete crop losses can occur.

What to Look For

Flag smut is characterised by long, black raised streaks on the leaves, leaf sheaths, awns and sometimes on the stems. These black streaks break through the plant tissue, revealing a mass of powdery grey-black spores which easily rub off onto a finger (Figure 6.6). Infected plants are often stunted so they are not always easily identified in the crop during the season. As well as being stunted, infected stems are often distorted and seldom produce heads. Infected leaves do not expand fully and remain rolled and twisted. Infected plants may produce many tillers, but not all tillers on a plant will exhibit symptoms.

Disease Cycle

During harvest the black spores are released from the plant contaminating both seed and soil. Typically, spores survive in soil for 3 years, but can survive for up to 7 years.

Soil or seed borne spores infect the new wheat plant before emergence. Infection is favoured by early sowing into relatively dry and warm soils. Optimal temperature for infection is 20°C, but infection may occur at as low as 5°C and as high as 28°C. The fungus grows inter and intra cellularly between vascular bundles of the leaf tissue and other effected plant parts.

Management

The regular use of fungicide seed treatments will control this disease. Avoiding the more susceptible varieties will also help control flag smut. Consult a current cereal disease guide for flag smut resistance/susceptibility ratings. See further information section for details. Following a flag smut outbreak, it is important not to sow wheat back into that paddock for several years and source clean seed.

Figure 6.6. Characteristic symptoms of flag smut in wheat are the black lines along the leaves that can easily rub onto a finger leaving a black mark (Unknown)

COVERED SMUT OF BARLEY

Covered smut of barley is caused by the fungus *Ustilago segetum* var. *hordei* (formerly *U. hordei*). This is a different fungus to that causing covered smut of wheat. This disease is generally well controlled because of the regular use of seed treatments.

Receival Standards

Grain Trade Australia's commodity standards have a nil tolerance for bunt in all grades of barley. See table 6.1.

What to Look For

Affected plants usually do not show symptoms until ear emergence. Infected ears typically emerge at the same time or slightly later than that of the healthy stems. Also, infected ears often emerge through the sheath below the flag leaf. All of the florets of infected ears are replaced by masses of dark brown to black spores. The spores of covered smut are held more tightly than those of loose smut (Figure 6.7).

Disease Cycle

During harvest the spores of effected heads spread and contaminate healthy grain. At sowing the smut spores germinate at the same time as the seed and infect the germinating plant. Infection of seedlings is favoured by earlier sowing as the fungus prefers drier soils and temperatures of 15-21°C. The fungus grows systemically within the plant, usually without producing symptoms and then it replaces the young grain with its own spores.

Management

Covered smut of barley can be effectively controlled by using fungicide seed treatments every year. Following infection new seed should be obtained from a clean source. Resistant varieties are available.

Figure 6.7. Covered smut on barley (Photo: Grant Hollaway — Agriculture Victoria)

LOOSE SMUT OF BARLEY

Loose smut of barley, like wheat, is caused by the fungus *Ustilago tritici* (*U. nuda*). However, the particular strain of loose smut that attacks wheat does not attack barley and vice-versa. In recent times loose smut has re-emerged as an issue in some Victorian barley crops. This issue has partly been attributed to increased susceptibility in some recent barley cultivars. Seed treatments provide effective control of this disease, but in the more susceptible cultivars the correct use of fungicidal seed treatments becomes even more important.

Receival Standards

The Grain Trade Australia commodity standards have a maximum tolerance of 0.1 gram of smut pieces per half litre in all grades of barley.

What to Look For

Symptoms of barley loose smut are similar to those of wheat loose smut. Until ear emergence affected plants often do not exhibit symptoms. Affected heads usually emerge before healthy ones and all the grain is replaced with a mass of dark brown spores (Figure 6.8). The spores are initially loosely held by a thick membrane that soon breaks releasing the spores onto other heads. Finally, all that remains is bare stalks where the spores once were.

Disease Cycle

As loose smuts of wheat and barley have similar life cycles see the section on the life cycle of wheat loose smut and Figure 5.5.

Management

Using high rates of systemic seed treatments with good coverage every year will effectively control this disease. Following a loose smut outbreak in a crop new clean seed should be sourced.

Figure 6.8. Loose smut of barley (Unknown)

SMUT OF OAT

Oats are affected by both loose (*Ustilago avenae*) and covered (*Ustilago segetum* var. *hordei*) smut. The field symptoms of these two diseases are often indistinguishable. The regular use of seed treatments effectively controls these diseases.

What to Look For

Smut infections of oats are usually not apparent until head emergence. At emergence, infected heads contain masses of dark brown to black spores that have replaced each grain. These spore masses are held in place by a thin membrane that often breaks allowing the spores to spread to healthy seeds (Figure 6.9).

Disease Cycle

Smut spores survive from one season to the next in contaminated seed lots. At sowing the smut fungus infects the emerging seedling. Infection is favoured by early sowing into warm seed beds. Following infection, the fungus grows systemically within the plant without producing symptoms. At flowering the fungus grows into the floret and replaces the developing grain with spores.

Management

Using systemic seed treatments every year will effectively control this disease. Following a smut outbreak in a crop new clean seed should be sourced.

Figure 6.9. Two smut affected oat heads compared with a healthy head (Unknown)

EXOTIC TO AUSTRALIA: KARNAL BUNT OF WHEAT

Karnal bunt, also known as partial bunt, is exotic to Australia. It is caused by the fungus *Tilletia indica*. It does occur in the USA, Mexico, India, Afghanistan, Pakistan and parts of Nepal and Iraq. Karnal bunt has major implications for trade as infected grain cannot be delivered to major export markets.

Like bunt of wheat, grain affected with karnal bunt also has a strong fishy odour. Closer examination of a seed lot affected by karnal bunt will reveal partially bunted seeds as only part of the grain is affected by disease (Figure 6.10).

Karnal bunt is most likely to enter Australia either on diseased grain or as spores on travellers' clothing. To prevent the introduction of this disease to Australia it is important that all seed imports to Australia occur through appropriate quarantine facilities, and that travellers to overseas farms thoroughly wash all clothing on return to Australia. Suspect samples must be reported immediately. Call the Exotic Plant Pest Hotline (1800 084 881).

Figure 6.10. Wheat grains affected by karnal bunt. Note that only part of the grain is bunted, this is a distinguishing feature between karnal bunt and covered smut

FURTHER INFORMATION

More detailed information can be obtained from;

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/biosecurity/plant-diseases/grain-pulses-and-cereal-diseases

Victorian Cereal Disease Guide

agriculture.vic.gov.au/cereal-disease-guide

Victorian Crop Sowing Guide

grdc.com.au/NVT-Victorian-Winter-Crop-Summary

Cereal Seed Treatment Guide (SARDI)

www.pir.sa.gov.au

AFREN | Australian Fungicide Resistance Extension Network

afren.com.au

Grain Trade Australia Commodity Standards

www.graintrade.org.au

SOIL-BORNE DISEASES

Authors: Dr Joshua Fanning (Agriculture Victoria) and Dr Grant Hollaway (Agriculture Victoria)

INTRODUCTION

Soil-borne diseases can be very damaging to field crop production. In extreme cases they can cause losses greater than 50 per cent, but often, due to their subterranean nature, losses go unrecognised. This lack of awareness and a lack of in-crop control options does make management of soil-borne diseases difficult.

Fortunately, DNA based soil testing (PREDICTA®B) provides the ability to identify paddocks at risk of damage from soil-borne diseases prior to planting, enabling appropriate management to be implemented to minimise losses.

Following is an overview of the identification and control of some of the important soil-borne diseases of Victorian field crops.

Soil-borne disease distribution

The pathogens of soil-borne diseases are widespread within Victorian cropping soils. In Victoria, the most common soil-borne pathogens of cereal crops are root lesion nematodes (RLN), crown rot, Rhizoctonia root rot, take-all and cereal cyst nematode (CCN). Within pulse crops soil-borne diseases are not very well understood. Surveys have shown a whole range of pathogens infect pulse roots and can cause disease. The relative yield losses due to these pathogens is currently unknown. Pathogens identified in recent projects include *Pythium* spp., *Pratylenchus* spp. (root lesion nematodes), *Fusarium* spp., *Rhizoctonia solani* AG8, *Phoma pinodella* *Aphanomyces* and *Phytophthora* genera. Figure 7.1 shows the relative prevalence of some of these pathogens

Even though soil-borne diseases are common, their level within a given paddock will vary depending on the region, soil type, the cropping history and weed burden. It is best to not generalise about pathogen distribution and monitor each paddock for the soil-borne diseases present based on testing.

Soil-borne Disease Identification

Effective management of soil-borne diseases begins with the accurate identification of pathogens in the paddock through either a soil test or inspection of plant roots for disease symptoms.

Soil Test

The PREDICTA®B soil test is the most accurate and comprehensive way of monitoring soil-borne pathogens in paddocks. This test can be used before sowing to identify paddocks at risk of soil-borne diseases, thus allowing high risk paddocks to be planted to another variety/crop to reduce the impact of soil-borne pathogens. The test can also be used in-crop to assist with disease diagnosis. When taking a soil test, it is important to correctly follow sampling protocols.

Inspection of Roots

To identify soil-borne diseases during the growing season, suspect plants can be dug up and their roots inspected. Plants should be sampled using a spade and not pulled out of the ground. This will ensure a good sample of roots is available for inspection. Soil is then carefully washed from the roots under running water. Roots are best inspected for disease by floating them in a white tray of water and looking for the different disease symptoms as described in this chapter.

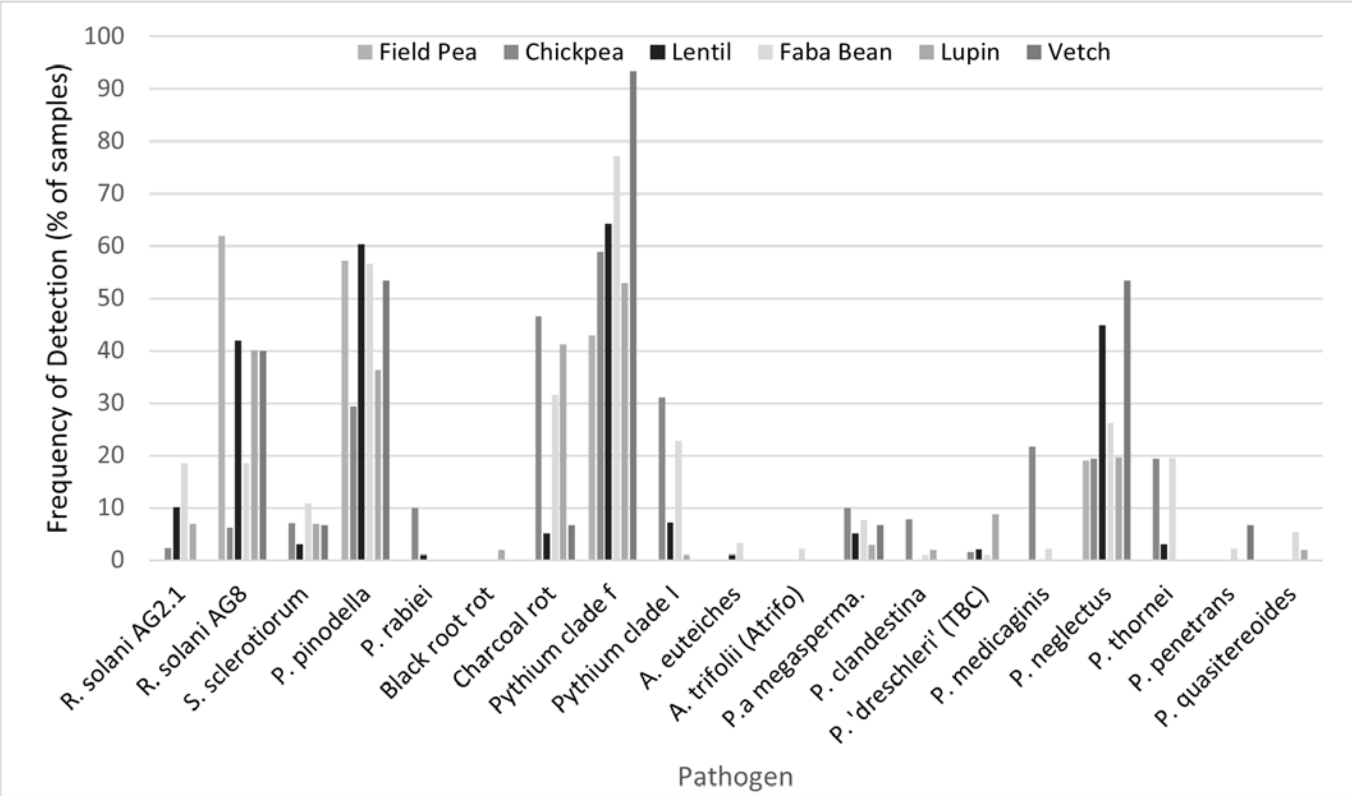


Figure 7.1. Frequency of detection of pulse pathogens within a National Soil-borne disease project during 2020.

Figure 7.2. Bare patches in a cereal crop caused by Rhizoctonia

Figure 7.4. Characteristic spear tipping on primary and secondary roots, caused by Rhizoctonia solani *(AG-8)*

Figure 7.3. Stem purpling caused by Rhizoctonia solani *(AG-8)*

Figure 7.5. Characteristic spear tipping mostly on the secondary roots, caused by Rhizoctonia solani *(AG-8) (Photo: Agriculture Victoria)*

RHIZOCTONIA ROOT ROT

Rhizoctonia root rot is a widely distributed fungal soil-borne disease found on a range of field crops and pastures. In severe cases it causes bare patches in paddocks (Figure 7.2), but yield loss still occurs even when patches aren't present. Unfortunately, resistant cultivars are not available, so control is reliant on cultural practices such as targeted cultivation, control of the green bridge, good nutrition and more recently fungicidal options have become available.

What to Look For

Bare patches may appear in the crop from an early growth stage and form areas of stunted plants. Bare patches may vary in size from a few centimetres to several metres in diameter (Figure 7.2).

Diseased plants are usually stunted and sometimes appear purple in colour (Figure 7.3). Diseased roots show brown lesions on the outside of roots. If the roots are severely infected the root cortex will be affected with the root easily breaking, leaving the characteristic brown 'spear tips' (Figures 7.4 and 7.5).

Disease Cycle

The Rhizoctonia fungus (*Rhizoctonia solani*) is a weak, unspecialised pathogen that can attack immature cereal roots, but not mature plant roots or stem tissue. Therefore, the primary or seminal roots are often attacked first, but later in the season immature secondary or nodal roots may also be attacked as they emerge (Figures 7.4 and 7.5).

Rhizoctonia solani (AG-8) survives between crops in particles of plant residue (organic matter) in the top 5-10 cm of soil (Figure 7.6). The fungus grows out of this material following autumn rains and spreads rapidly through the soil forming a hyphal (cobweb) net. The roots of germinating plants are infected when they grow into the hyphal net. The fungus is most active at temperatures between 10°C and 15°C.

Rhizoctonia solani (AG-8) has a saprophytic phase and a parasitic phase. However, the phases are not completely independent as both saprophytic and parasitic hyphae can be active in the soil at the same time. In this respect, Rhizoctonia differs from specialised pathogens like the take-all fungus in that it can move freely through the soil and the saprophytic phase can be active over the summer.

Stubble acts as a substrate for saprophytic growth of the fungus and provides a means for the fungus to survive over the summer. Cereal straw, a material with a high Carbon:Nitrogen ratio, favours the multiplication of *Rhizoctonia solani* (AG-8) in the soil. However, research has shown that the high stubble loads in conservation cropping systems also encourage the build-up in soil microbes that suppress the activity of Rhizoctonia. This suppressive activity has been shown to increase over a five to eight-year period. Rhizoctonia inoculum often increases during the first few years following the adoption of conservation cropping systems, but reduces once suppressive microbe populations increase. These microbial populations suppress the activity of Rhizoctonia and reduce the seasonal impacts of this disease.

Soil moisture plays an important role in Rhizoctonia survival. The fungus can grow below the permanent wilting point and survive dry summers. This gives it a competitive advantage and disease damage is often severe following dry summers. However, summer rainfall (more than 20 mm in a week) will reduce inoculum as the fungus does not compete well with other soil microorganisms in a warm and moist environment.

Rhizoctonia root rot is more likely when:

- conditions are dry over the summer
- weed growth is not controlled before sowing
- there is no soil disturbance before sowing
- late sowing into cold soils slows down plant root growth and the roots do not grow away from the fungus
- the soil is compacted
- soil fertility is low, especially P, N and Zn
- sulfonylurea herbicides were used on soils conductive to Rhizoctonia.

Management

Rhizoctonia management is challenging due to its wide host range and lack of genetic resistance within crops. Strategies such as weed control, crop rotation, fungicides and sowing practice can all contribute to Rhizoctonia suppression.

Rhizoctonia multiplies on weed roots so it is imperative to control weeds. If weeds are established, a 3 to 4 week chemical fallow prior to sowing will reduce disease damage. In a season with a late break it is not advisable to delay sowing past the optimum sowing date.

Adequate plant nutrition can reduce the effects of Rhizoctonia but should be used with other management practices. Applying additional nitrogen, phosphorus and zinc can reduce yield losses due to Rhizoctonia.

Soil disturbance has, in many instances, proved effective in controlling Rhizoctonia. However, multiple cultivations before sowing are not necessary, provided weeds are controlled and there is a single deep cultivation (50 to 100 mm under the seedbed) in the fortnight prior to sowing. The soil disturbance prior to sowing works by breaking up the web of Rhizoctonia fungus in the soil providing an advantage to the newly emerging seedling.

In a direct drilled operation, a depth modified seeder that disturbs the soil 50 to 100 mm under the seedbed while sowing at the correct depth, will provide enough soil disturbance to reduce disease damage. This can be done by using a long narrow point or by having cultivating tynes working directly in line with, but 50 to 100 mm deeper than sowing tynes. It may be necessary to use a deflector plate with the long narrow point to prevent the seed dropping to the furrow bottom.

Hosts

Rhizoctonia has a wide host range and all crops, pasture and weed species grown in rotations are susceptible. There are no resistant cereal varieties and crop rotations are not effective in controlling this disease. However, rotations that include a canola or mustard crop will lower the level of Rhizoctonia inoculum in the soil, but they must be free of grasses.

Chemical

Research has demonstrated that fungicides when used as part of an integrated approach to Rhizoctonia control can help reduce disease severity. In GRDC funded trials in southern Australia and Western Australia, on average seed treatments gave 5 per cent (0 to 18 per cent) yield responses in wheat and barley. Other studies using fungicides registered for liquid banding at planting also showed improvements in Rhizoctonia control.

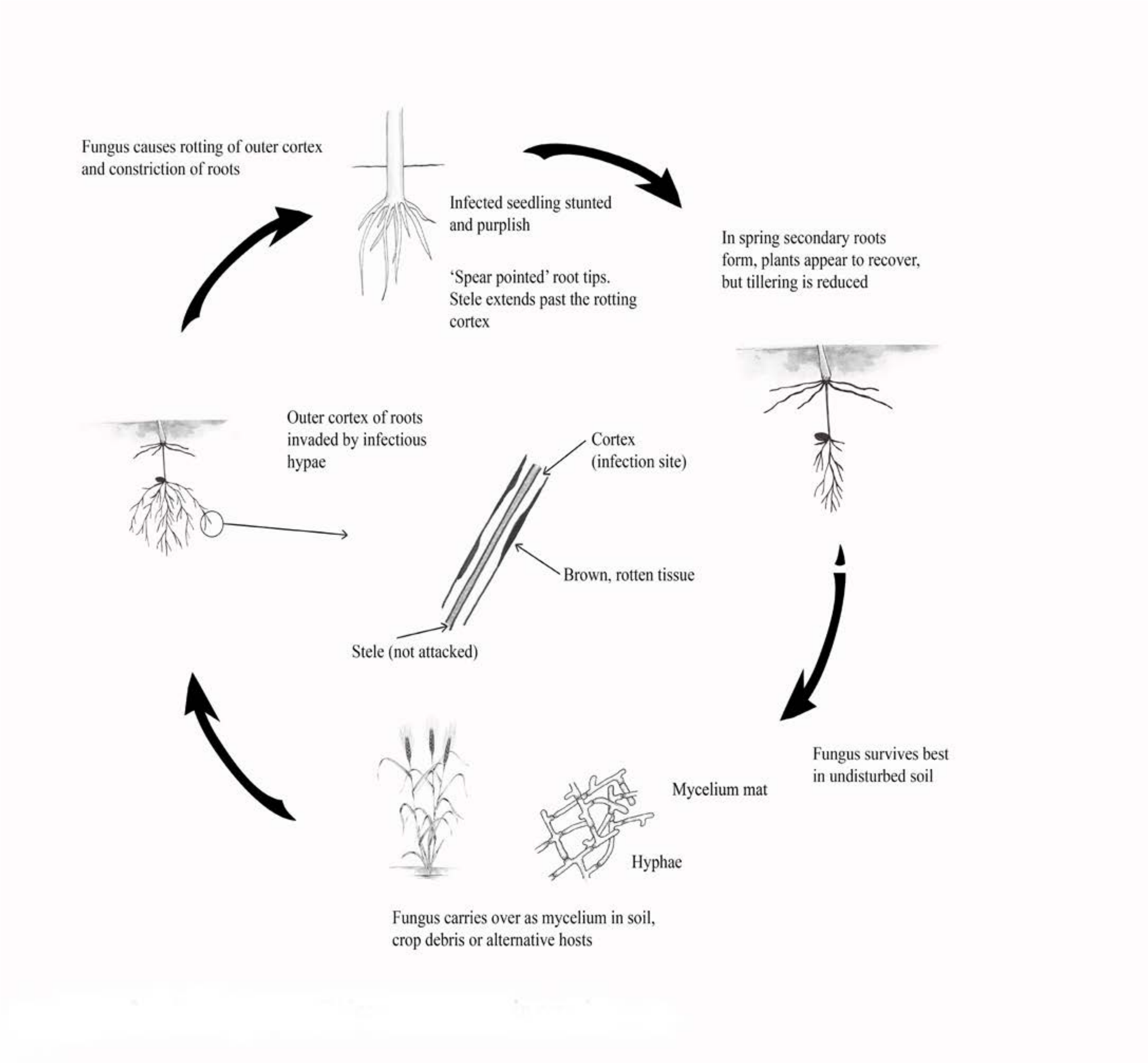


Figure 7.6. Disease cycle of Rhizoctonia root rot in cereals. Illustration by Kylie Fowler

ROOT LESION NEMATODE (RLN)

The two important species of root lesion nematode (RLN) in Victorian cropping soils are *Pratylenchus neglectus* and *Pratylenchus thornei*. They often occur together. Both species can cause grain yield losses in most crops, but the greatest yield losses have been measured in wheat, barley and chickpea. Even though root lesion nematodes are present in up to 90 per cent of paddocks in Victoria, they are only present in yield limiting quantities in approximately 10 to 20 per cent of paddocks. Therefore, it is important to test individual paddocks to determine if they are likely to impact yield.

What to Look For

In the field, above ground symptoms of root lesion nematodes include stunted plant growth, uneven patches or waviness across the paddock, but often they can reduce yield without obvious above ground symptoms. The two main root symptoms include lesions or discolouration of the roots and a lack of branching along the main roots (Figure 7.7). They do not cause roots to swell, but appear brown or constricted where infestation of the root cortex has occurred. These symptoms are similar to Rhizoctonia, but the characteristic spear tipping associated with Rhizoctonia is absent.

Disease Cycle

Root lesion nematodes are worm-like organisms less than 1 mm in length which feed on and within roots (Figure 7.8). Root lesion nematodes have more than one generation per season and are able to migrate between and within the roots and soil (Figure 7.9). These nematodes survive over summer either as eggs or in a dehydrated state, becoming active again once soil moisture is available.

Economic Importance

In the southern region, field trials between 2012 and 2016 showed that RLN can cause yield losses of 5 to 20 per cent in cereals. The risk of yield loss increases as the number of nematodes present at sowing increases (Figure 7.10). However, the effect on crop yield depends on seasonal conditions, the crop/variety and the numbers of nematodes present at sowing. Figure 7.10 highlights the yield loss in bread wheat, in a single variety over four different seasons associated with increasing pre-plant nematode densities. The risk of yield loss is reduced in seasons when there is no moisture stress on the crop during spring.

Management

If growing susceptible crops/varieties, a PREDICTA®B test can be used to monitor RLN populations and ensure they are not at densities known to cause yield losses. When susceptible crops are grown consecutively, they lead to high nematode populations (Figure 7.11). The yield loss caused by RLN is related to the number of nematodes present in a paddock (Figure 7.10). Rotation to resistant crops reduces RLN densities (number) in the soil and provides the best option for their control. In contrast, rotations with susceptible crops increases RLN densities and yield loss in subsequent intolerant crops. Rotations are the best way of controlling RLN.

Resistant crops can reduce nematode populations by up to 50 per cent in one year. A break of two or more years from susceptible crops may be necessary to minimise yield loss if nematode numbers were high to start with. Avoid delayed sowing of intolerant cereal crops.

Hosts

Root lesion nematodes have a broad host range that includes cereal and broadleaf crops. Table 7.1 summarises the host range. However, always check current cereal and pulse disease guides for the latest ratings.

RLNs are more likely to be a problem when:

- susceptible varieties are grown sequentially increasing nematode numbers
- an intolerant crop is sown, or
- sowing is delayed.

Figure 7.7. Roots infected with Pratylenchus *nematodes have dark lesions and lack lateral roots.*

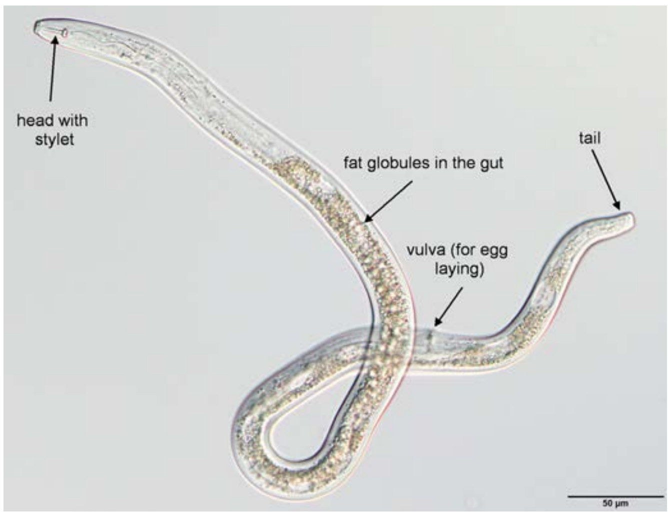
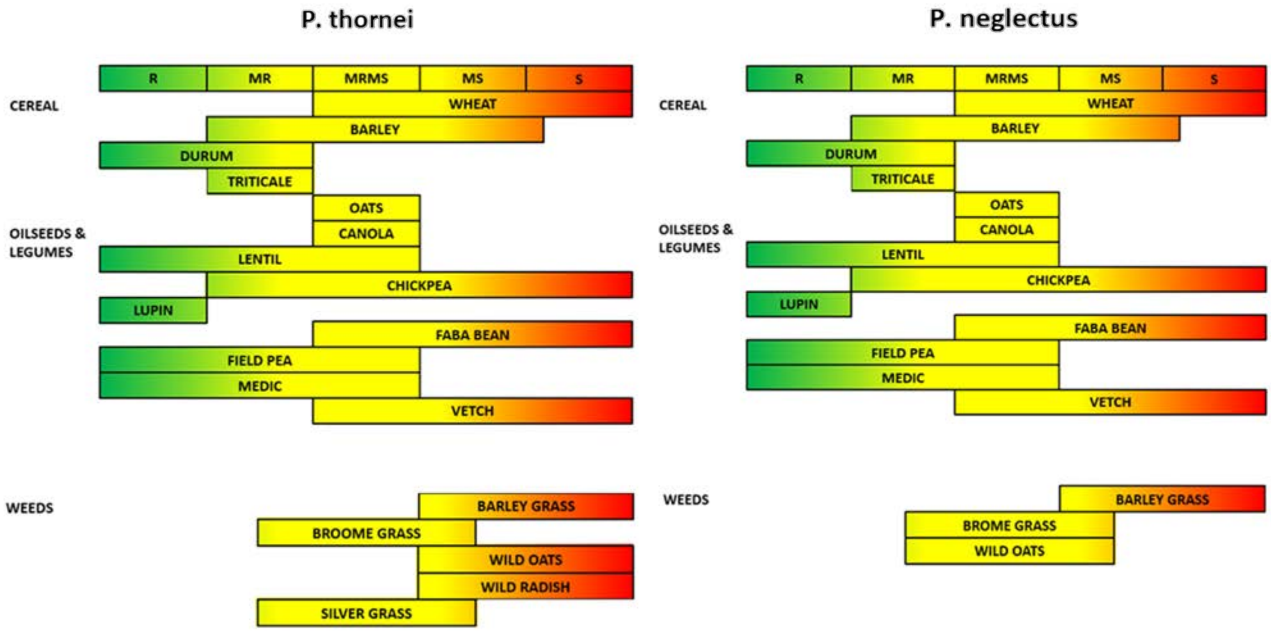


Figure 7.8. Pratylenchus thornei *adult female, approximately 0.65 mm in length (Image: Kirsty Owen, University of Southern Queensland)*

Table 7.1. Hosting ability of crops to the two common species of root lesion nematodes



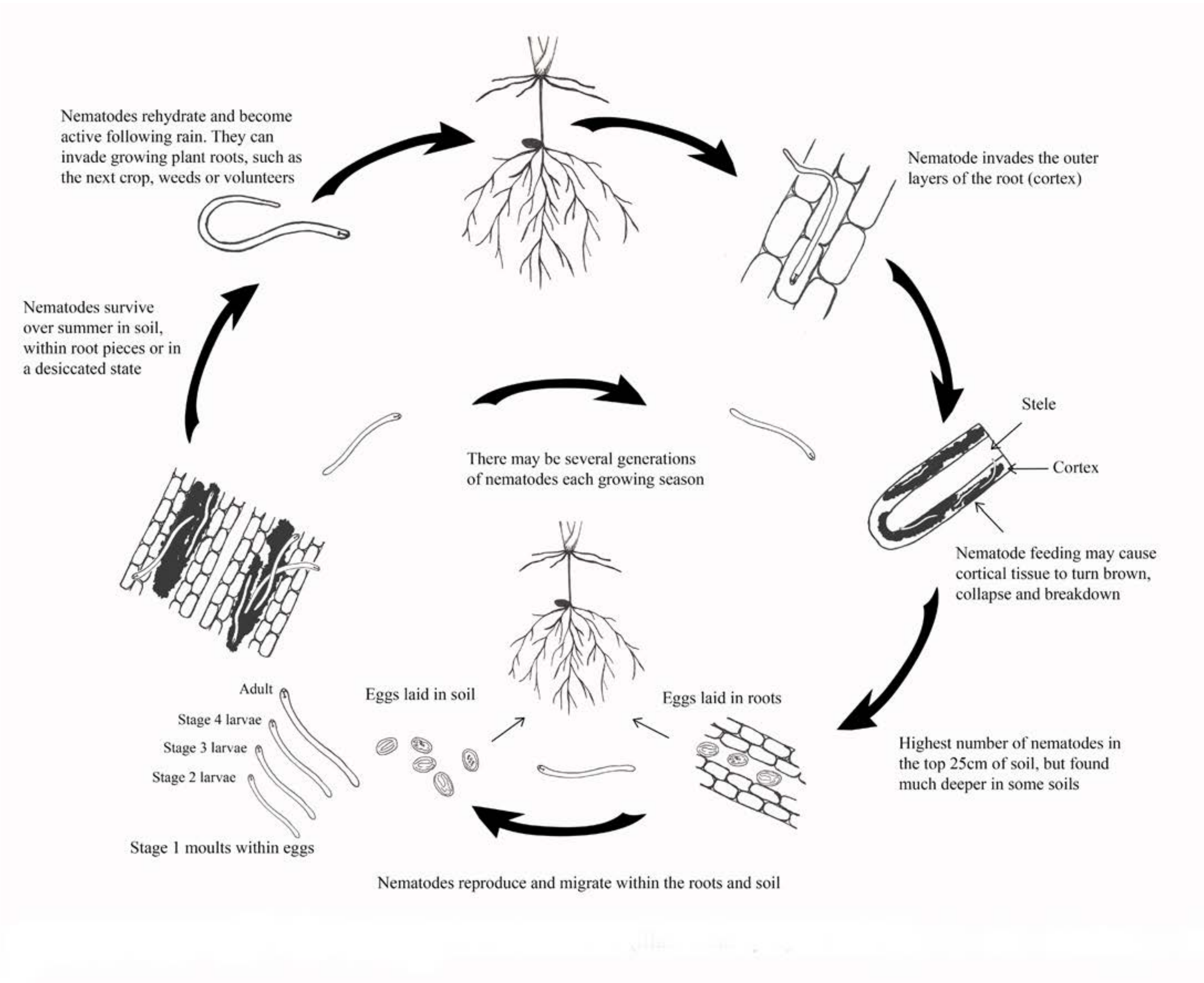
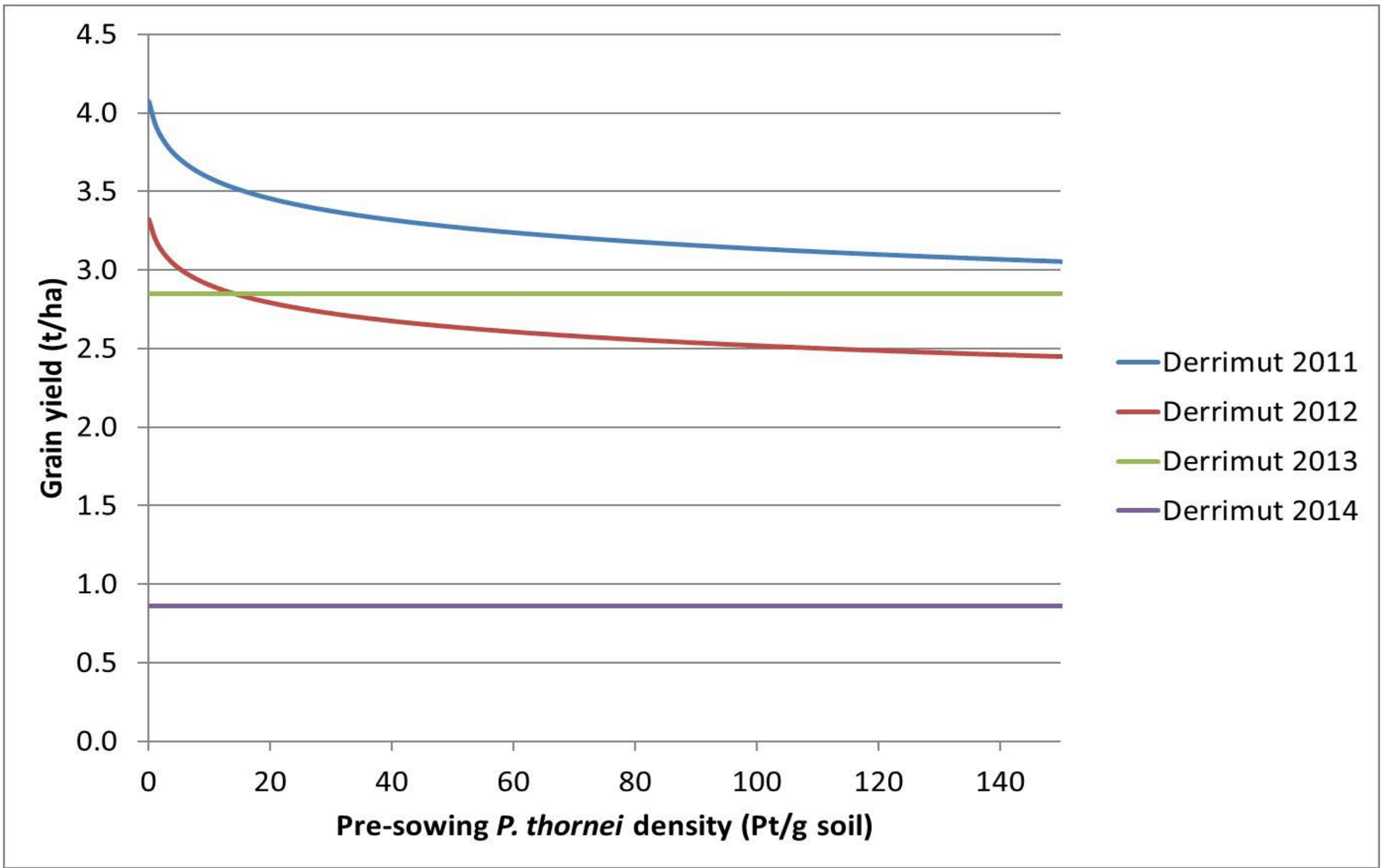


Figure 7.9. Disease cycle of root lesion nematode in cereals. Ilustration by Kylie Fowler



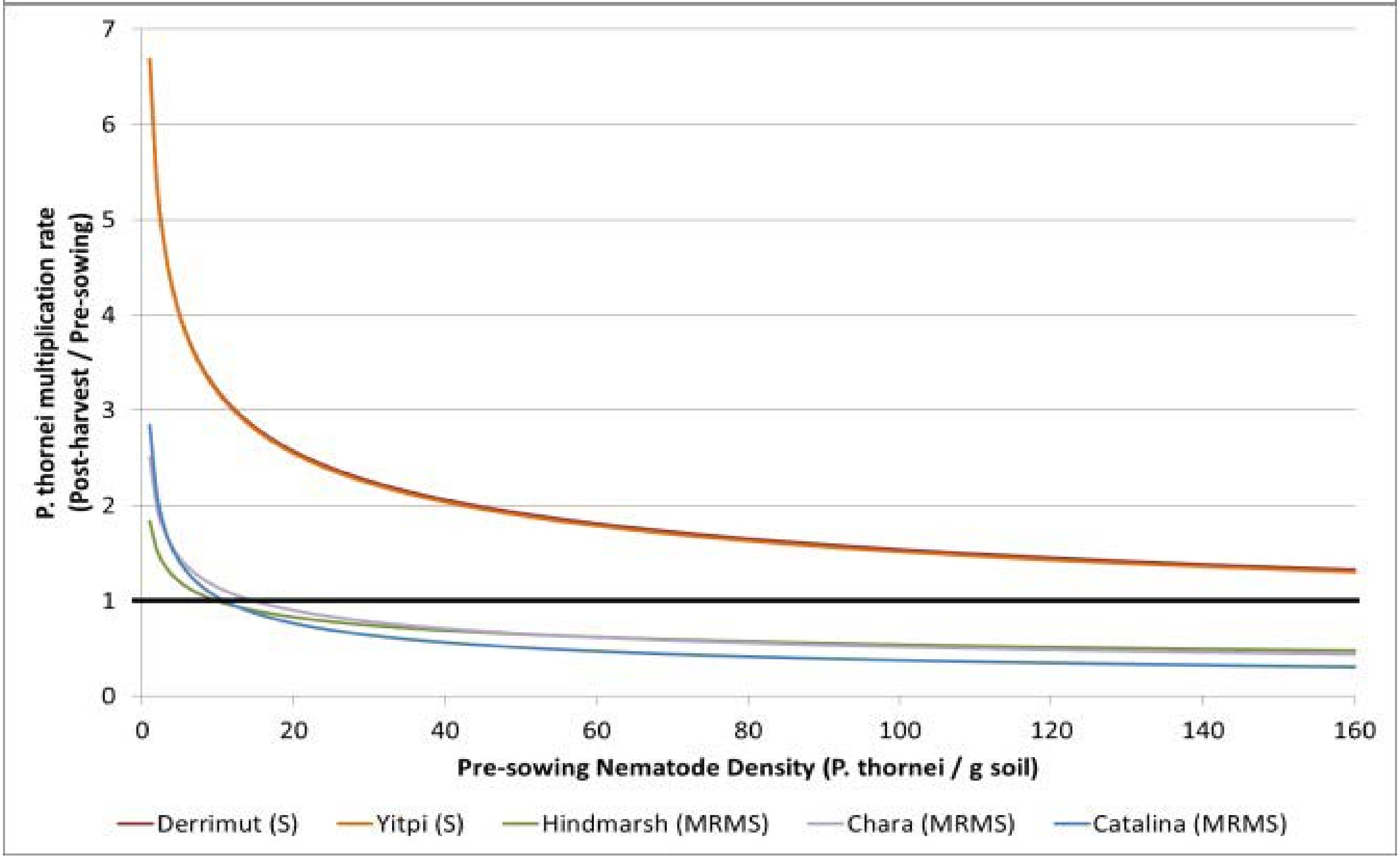


Figure 7.10. (Top). Relationship between pre-planting density of Pratylenchus thornei *in the soil and grain yield of wheat (cv. Derrimut) in four different seasons in the Victorian Wimmera 2011-2014.*

Figure 7.11. (Bottom). Relationship between pre-planting number of Pratylenchus thornei *and their multiplication rate in the presence of five cereal varieties with contrasting resistance / susceptibility. Data based on five seasons (2011 to 2015) of field data from Banyena, Victoria.*

CEREAL SOIL-BORNE DISEASES
CROWN ROT

Crown rot, the most important soil-borne disease of cereals in Victoria, is an important disease in stubble retained cereal intensive cropping systems. Yield losses from crown rot are greater in season with a dry finish, compared to those with a wet spring. During seasons with below average rainfall crown rot causes whiteheads to develop in wheat crops resulting in yield losses of -5 to >20 per cent. Yield losses in durum wheat are much greater than in bread wheat and can be more than 50 per cent.

The first step in controlling crown rot is to identify paddocks at risk. This can be done using a PREDICTA®B test before sowing, or through inspection of stem bases for symptoms of crown rot in a previous cereal crop. In paddocks with a high crown rot risk, rotation to non-cereals can reduce inoculum levels, while in paddocks with medium crown rot risk, avoiding durum and bread wheats can prevent large losses. There are a range of strategies that can contribute to reducing losses associated with crown rot.

Figure 7.12. Crown rot causes deadheads that are usually found on scattered plants or single tillers in the crop.

What to Look For

The symptoms of crown rot are most obvious on wheat plants close to maturity when diseased plants pre-maturely form white heads, also known as dead heads. The deadheads are either empty or partially filled with shrivelled grain (Figure 7.12). Affected plants may be scattered across a paddock or occur in patches, often close to trees. In addition to causing white heads, the fungus may also cause a seedling blight which can result in either pre- or post-emergent death. Plants affected by crown rot may be stunted and produce fewer tillers.

Disease symptoms on the base of plants include honey brown discolouration of the crown, lower leaf sheaths and tillers (Figure 7.13). Symptoms can extend up the stem where the fungus may form pink spore masses at the nodes (Figure 7.14). By comparison, plant roots and crowns affected by take-all are distinctly black in colour (See Figures 7.17 and 7.19 in the take-all section).

Figure 7.13. Honey discolouration on stem caused by the crown rot fungus

Disease Cycle

The crown rot pathogen (*Fusarium pseudograminearum* and/ or *Fusarium culmorum*) can survive for up to two years on infected cereal stubble from previous cereal plants, volunteer cereals or grass weeds. For this reason, stubble management is an important aspect in the control of crown rot. Survival is enhanced by dry summer conditions, but infection of the young crop is favoured by moist humid conditions with temperatures between 15°C and 20°C (Figure 7.15).

Figure 7.14. Honey discolouration stem and pink fungal growth caused by the crown rot fungus

Management

Crown rot management relies on:

- identification of paddocks at risk
- strategies that reduce inoculum levels
- strategies that minimise losses in cereals.

There are no in-crop fungicide options for the control of crown rot.

Identification of paddocks at risk

The risk from crown rot in a paddock can be identified prior to planting, thus enabling losses from crown rot to be avoided. Either a PREDICTA®B test or inspection of stem bases for symptoms of crown rot in a previous cereal crop can be used to identify crown rot risk. Research has clearly shown that higher inoculum levels in a paddock at planting results in greater yield losses in seasons conducive for crown rot to occur.

It is important when taking a PREDICTA®B test that the crowns/stem bases of previous cereal crops is included within the sample. It is within the old cereal bases where the crown rot inoculum survives, so if this is removed from the testing sample the risk posed by crown rot will be under-estimated. The results from the PREDICTA®B test provide an estimate of risk for that paddock.

Crown rot risk can also be estimated based on symptoms on cereal stem bases. Ideally inspect cereal crops between grain filling and harvest. Collect plant samples from the paddock by walking a large 'W' pattern, collecting five plants at each of 10 locations. Examine each plant for basal browning and record the percentage of plants that show symptoms. In general, the risk of crown rot for the next season will be:

- LOW – less than 10 per cent of plants infected;
- MEDIUM – 10 to 25 per cent of plants infected; and
- HIGH – more than 25 per cent of plants infected.

Reducing crown rot inoculum

Rotations

A grass free break from cereal decreases crown rot inoculum. The actual break crop used (e.g. oilseed, pasture, legume, fallow) does not make a large difference, so select a break crop most suited to the farming system.

Good rainfall increases the effectiveness of a break, as the cereal residues harbouring the pathogen are more readily decomposed by microbes during moist conditions.

For break crops, early canopy closure and warm, damp conditions under the canopy will result in the fastest decomposition of crown rot-infected plant residues and therefore reduced inoculum levels.

Where disease levels are high and there is low rainfall, it may take around 2-4 years for infected plant residues to decompose to reduce disease risk to a low enough level to sow durum wheat.

Managing stubble

Since crown rot is stubble borne, any strategies that accelerate the breakdown of stubble will also reduce the risk from crown rot. Within the plant the crown rot inoculum is more concentrated in the crown and the bottom seven centimetres of the stem.

Stubble management practices such as cultivating, spreading, slashing and grazing can increase the rate of stubble decomposition in the medium to long term. However, in the short term these practices can increase crown rot risk as they can increase the number of infected stubble pieces that can touch new crop plants and increase infection rates in the crop.

Fragments of stubble may be hard to see with the human eye, but even small fragments can carry the disease. PREDICTA®B testing is the most accurate way to determine these levels and avoiding planting cereals into paddocks at risk of loss from crown rot.

Reducing yield loss in cereals

If a cereal must be sown in a paddock with an identified risk to crown rot, there are strategies that can be adopted to minimise losses. Crop selection (i.e. avoiding cereal crops such as durum wheat which are prone to high yield loss) can reduce losses from crown rot and strategies such as inter-row sowing and time of sowing can also contribute to reducing losses.

Cereal type

As shown in Figure 7.16, cereal crops differ in their yield losses due to crown rot. Therefore, if a cereal is to be grown in a paddock with a crown rot risk, yield losses will be less if barley or oats are grown in preference to wheat or durum.

Note that even though barley has reduced yield loss from crown rot, it still increases inoculum levels which will increase the crown rot risk in that paddock. To reduce crown rot levels and avoid losses it is best to rotate to a non-cereal break. Barley most likely escapes yield loss due to its early maturity enabling it to finish before there is water stress at the end of the season.

Within wheat cultivars there is some variation in the extent of yield loss caused by crown rot and selecting more tolerant cultivars can reduce some yield loss. Also, GRDC is supporting pre-breeding research to develop wheat cultivars with improved resistance to crown rot to further improve the ability of future wheat cultivars to yield in the presence of crown rot.

Time of sowing

Sowing a variety early in its optimum sowing window will help minimise the detrimental effects of crown rot infection by bringing the grain-filling period forward into slightly reduced water stress conditions at the end of the season. However, this should be balanced against any increase in the risk of frost damage in your area.

Inter-row seeding

If cereals are to be planted into a paddock at risk of crown rot, the extent of the loss can be reduced by inter-row sowing. Since the majority of the crown rot inoculum is located in the stem bases of the previous cereal crop, planting in the inter-row increases the distance between the new crop and the old infected plants, thus decreasing the level of infection in the new crop.

Studies in the southern and northern regions have shown that planting in the inter-row can decrease the number of infected plants by about 50 per cent thus providing a small reduction in the extent of yield loss caused by crown rot.

Crop nutrition

As crown rot is more severe when a crop suffers from water stress late in the season, it is important to match nutritional inputs to expected yields and available stored water. Excessive early crop growth (bulky crops) can deplete stored soil water, increasing the risk of water stress during grain filling, particularly in seasons where water is more limiting.

Ensure crops have adequate zinc nutrition, as whitehead expression can be more severe in zinc-deficient crops. Applying zinc above recommended rates will not provide further protection from crown rot.

Seed Applied Fungicides

There are no in-crop fungicide control options for crown rot. There are some seed treatments that may provide partial suppression of crown rot. These may be an advantage when used in conjunction with other management options.

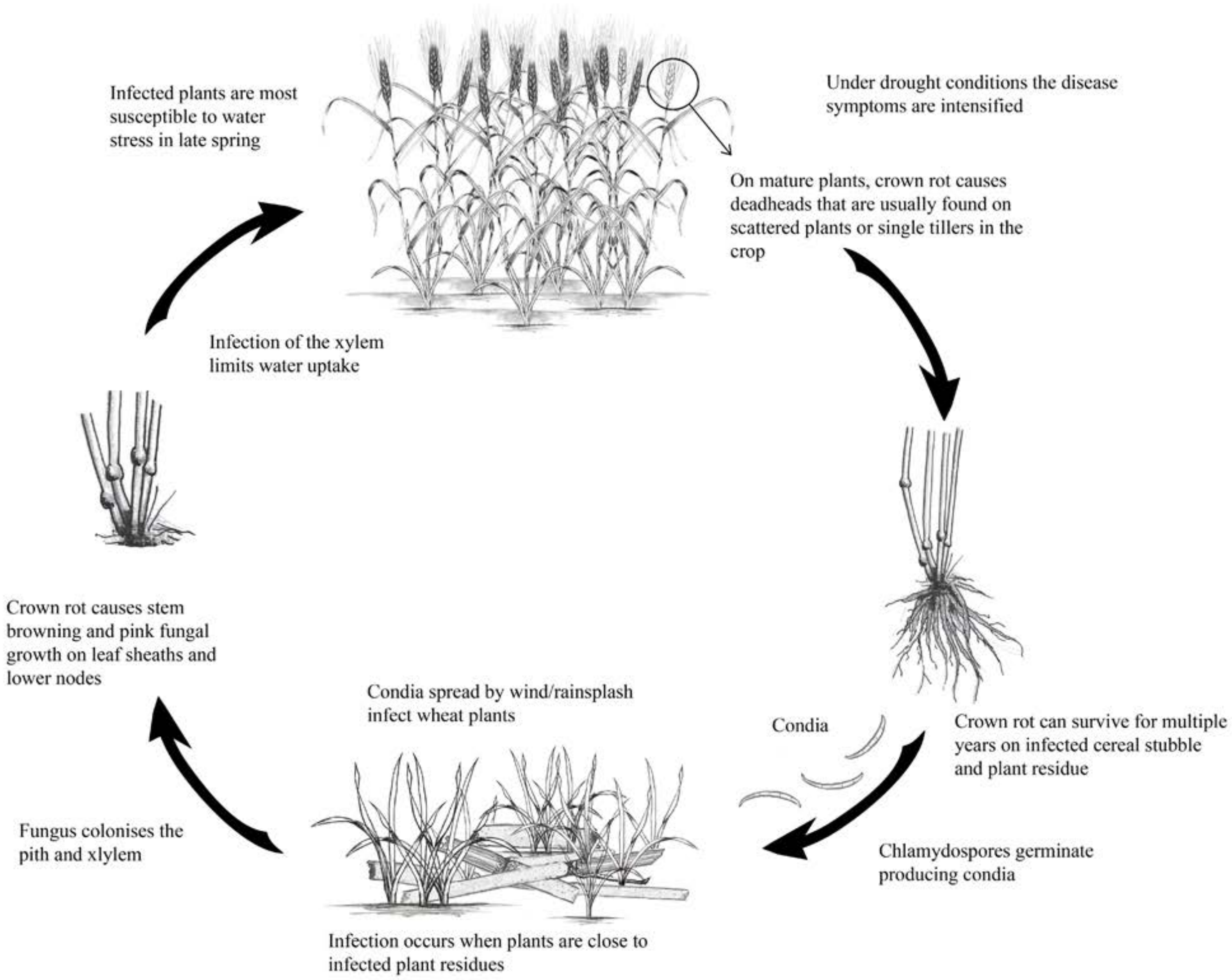


Figure 7.15. Disease cycle of crown rot in cereals. Illustration by Kylie Fowler

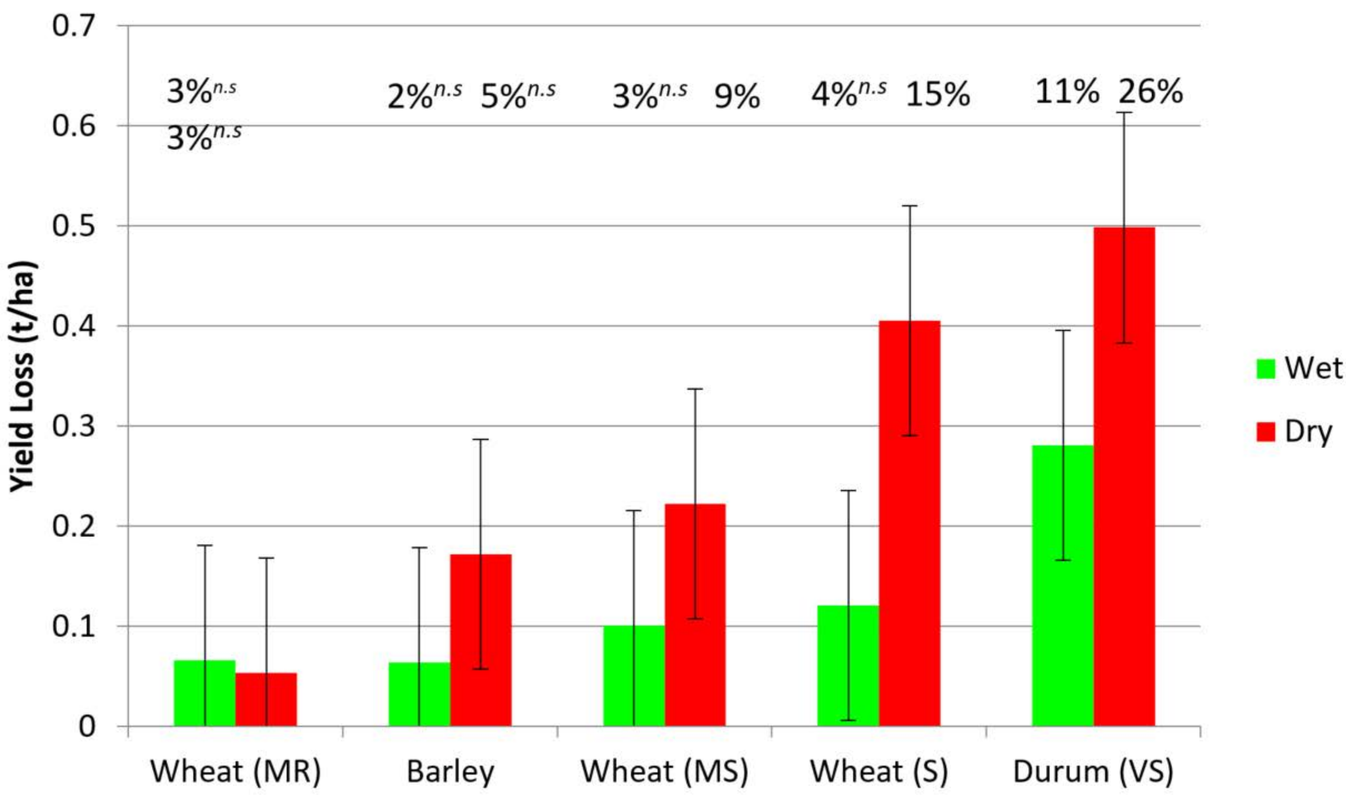


Figure 7.16. Yield loss in cereals based on an analysis of 43 field experiments conducted in Victoria and South Australia in both wet (above average combined September and October rainfall) and dry seasons (below average combined September and October rainfall): 1998 to 2015.

TAKE-ALL (HAYDIE)

Take-all is an important soil-borne disease of cereals, that is worse following seasons with a wet spring. Take-all can be controlled with a one-year grass free break from cereals and there are chemical control options available at planting. In recent years the importance of Take-all has reduced as a cereal root disease as a result of better grass weed control in the cropping system.

What to Look For

The most obvious symptom of take-all is the presence of whiteheads during grain fill (Figure 7.18). Whiteheads caused by take-all are typically present in patches in contrast to whiteheads caused by crown rot which are usually spread across an area (Figure 7.12). Inspection of stem bases will often show a distinct blackening (Figure 7.19). The whiteheads form as the Take-all fungus blocks the water conducting tissue in the plant restricting water uptake. Low soil moisture during October and November increases the occurrence of whiteheads.

Inspection of plant root shows the unique symptom of Take-all, blackening of the roots (Figure 7.17). The Take-all fungus gets into the centre of the root (stele) so that when roots are snapped and observed end on, the root is black in its core.

Disease Cycle

Take-all (*Gaeumannomyces graminis* var. *tritici*) can only survive between susceptible cereals in the root and tiller bases of previously infected plants. Following autumn rains, the Take-all fungus grows out of this material and attacks the roots of susceptible plants. In the absence of hosts, the fungus is unlikely to survive more than one year. The build-up of Take-all is greater during wet springs, but its carry over is reduced following significant summer rain events (i.e. >25 mm in a single event) (Figure 7.20).

Management

A PREDICTA®B soil test prior to planting can identify paddocks at risk of damage from Take-all. Should a paddock be identified with a take-all risk then appropriate management can be implemented.

Plan ahead and have a grass free break in the year before cropping. Start fallow or remove grass weeds from break crops before the end of July (end of June in the Mallee) to prevent the fungus multiplying and being carried into the next crop. This will also give plenty of time for plant debris, in which the fungus survives, to break down.

Ensure crop rotations are in place, with pulses, oilseeds or oats (if oat strain is not present) to provide a break to ensure the reduction of take all inoculum. A single year break will usually be adequate, however, where this break is a drought year a further year may be required.

Chemical treatments applied to seed or fertiliser are available to reduce the impact of Take-all if sowing into paddocks with medium Take-all risk. It is best to avoid sowing cereals into paddocks with a high Take-all risk. Barley is more tolerant of Take-all than wheat. Delayed sowing can reduce the impact of Take-all by giving more time for inoculum break down before sowing. Little can be done for an infected crop during the season.

Summer rainfall events (>20 mm) can reduce Take-all risk by favouring microbial break-down of the inoculum. Each significant summer rainfall event reduces inoculum densities by approximately half.

Hosts

Take-all affects cereals and grasses so non-cereal crops (e.g. pulses and oilseeds) will provide a break. Where the oat strain is present, oats should also be avoided as they will be affected by Take-all. A PREDICTA®B test can identify if the oat attacking strain of Take-all is present within a paddock.

Figure 7.17. Take-all infection of wheat seedling. The blackening of the roots, with the black fungal growth present in the centre of roots a useful diagnostic feature.

Figure 7.18. Patches of deadheads caused by take-all.

Figure 7.19. Severe take-all symptoms on mature plant showing blackened roots, sub-crown internode and crown.

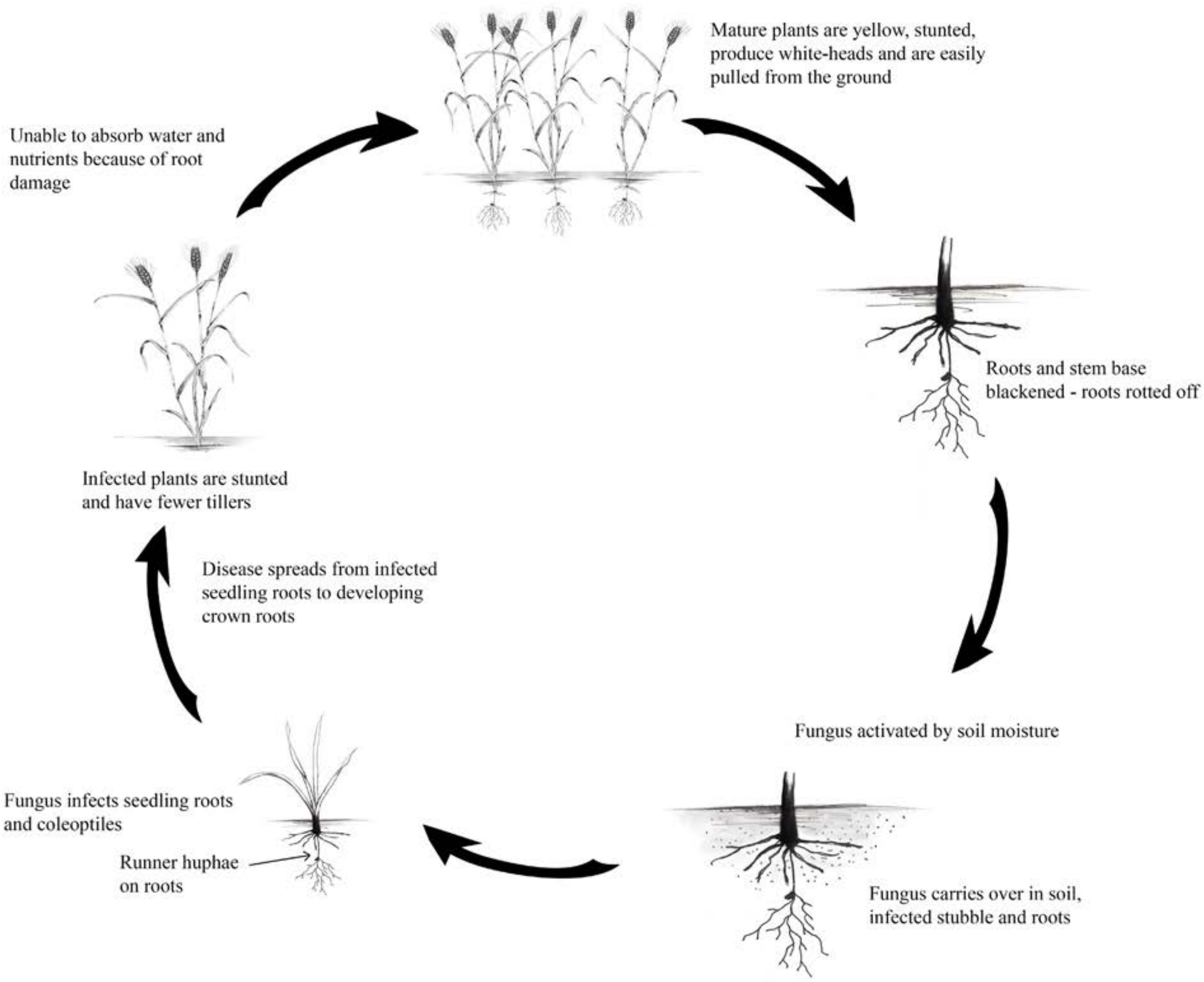


Figure 7.20. Disease cycle of Take-all in cereals. Illustration by Kylie Fowler

CEREAL CYST NEMATODE (CCN)

Cereal cyst nematode was the most damaging soil borne disease of cereal crops in southern Australia prior to the widespread adoption of resistant cultivars during the late 1990s. Losses from this disease are now rare but do still occur where nematode densities have increased when there is a high proportion of susceptible cereals sown in the rotation.

What to Look For

In-crop, CCN causes plant stunting and yellowing, which often gives the crop a 'patchy' appearance (Figure 7.21). However, recent field experiments have shown no visible symptoms of CCN infection, but greater that 20 per cent yield loss has been observed. This highlights the importance of inspecting plant roots for symptoms. Affected plant roots show abnormal branching and knotting (Figure 7.22). Symptoms can be confirmed at flowering time by the presence of small white 'cysts' (1-2 mm in diameter) that are attached to the roots (Figure 7.23).

Disease Cycle

Cereal cyst nematode (*Heterodera avenae*) survives between susceptible cereal crops as eggs inside protective brown cysts (Figure 7.24 and 7.25) that form on the roots of host plants. In the autumn, nematodes hatch from eggs in response to moisture and low temperatures (<15°C) (Figure 7.26). Nematodes hatch over a period of several weeks, with the peak hatch occurring about six weeks after the autumn break. In a further eight weeks these nematodes will form viable eggs. Therefore, to prevent CCN multiplying, it is necessary to control host plants within 10 weeks of crop germination.

Each year approximately 85 per cent of eggs hatch from cysts after the autumn break, while the remaining 15 per cent stay dormant until the following season. Therefore, it takes at least two years with break crops to control CCN. However, under very dry (drought) conditions more eggs remain dormant and an extra year of break crop is advisable.

Management

In general, CCN is well controlled and will only become a problem if grass weeds are not effectively controlled or CCN susceptible cereals are being grown more frequently than once every three years. If grass weeds are not managed or susceptible cereals are being grown, then paddocks should be monitored for CCN levels using a PREDICTA®B test.

Should a paddock be identified with a CCN problem then plan at least a two-year break from susceptible cereals and manage grass weeds. Extra time may be required in drought years. Timing of host removal is critical when establishing a disease break. In calculating the critical date to remove host species from break crops (i.e. grass weeds) consideration should be given to the time taken for host plants to die after herbicide application. Nematodes continue to feed until the plant is dead.

Host plants, particularly wild oats and susceptible self-sown cereals must be controlled before the nematodes have completed the development of eggs. This is approximately 10 weeks after the autumn break.

The use of resistant cereals and non-host crops, or chemical fallow in rotations as part of a two-year break, is an effective method to control CCN.

Hosts

CCN has a narrow host range that is limited to cereals and some grass weeds. Susceptible cereals and wild oats are the most important hosts. Ryegrass, brome and barley grass are poor hosts. There are lots of cereal varieties that are resistant, so it is important to consult the latest disease ratings to determine your risk of increasing CCN densities in the Victorian Cereal Disease Guide or the NVT website.

Pulses, other legumes and oilseeds are non-host crops and CCN cannot feed or reproduce on their roots and therefore provide a good break. A chemical fallow can also provide a break if suitable in the rotation but is not necessary with many other cropping options available.

Figure 7.21. Severe crop yellowing and stunting caused by cereal cyst nematode. Photo by Grant Chennells, SARDI

Figure 7.22. Abnormal knotted wheat root system caused by cereal cyst nematode.

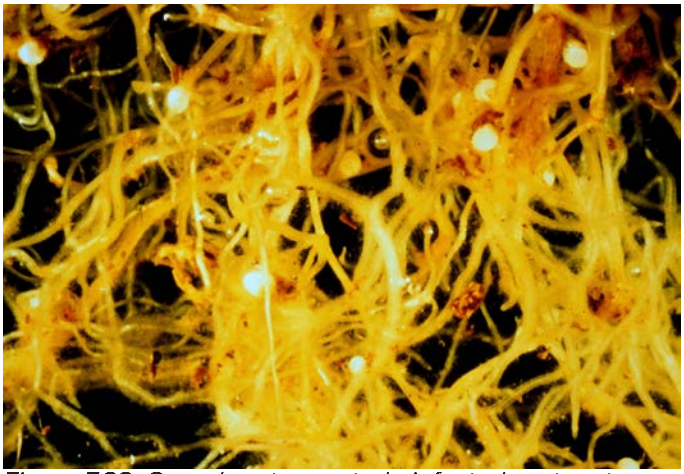


Figure 7.23. Cereal cyst nematode infected root system with white females.

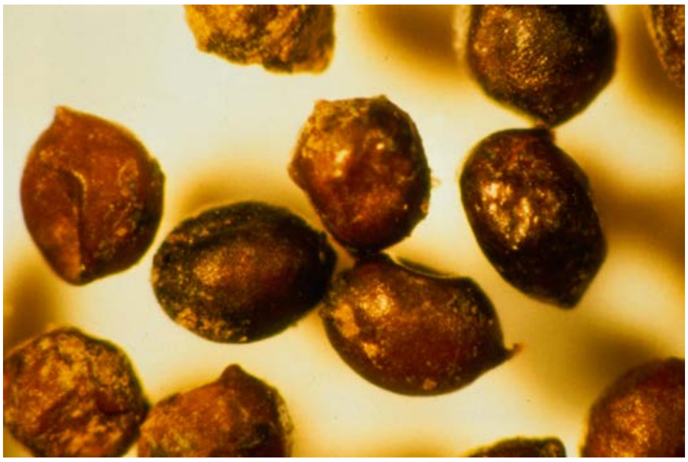


Figure 7.24. Brown cereal cyst nematode cysts carry the nematode over the summer.

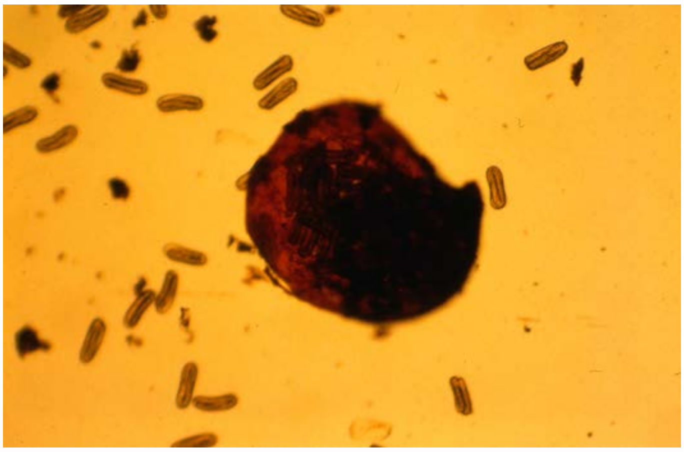


Figure 7.25. Cereal cyst nematode eggs hatching from brown cyst.

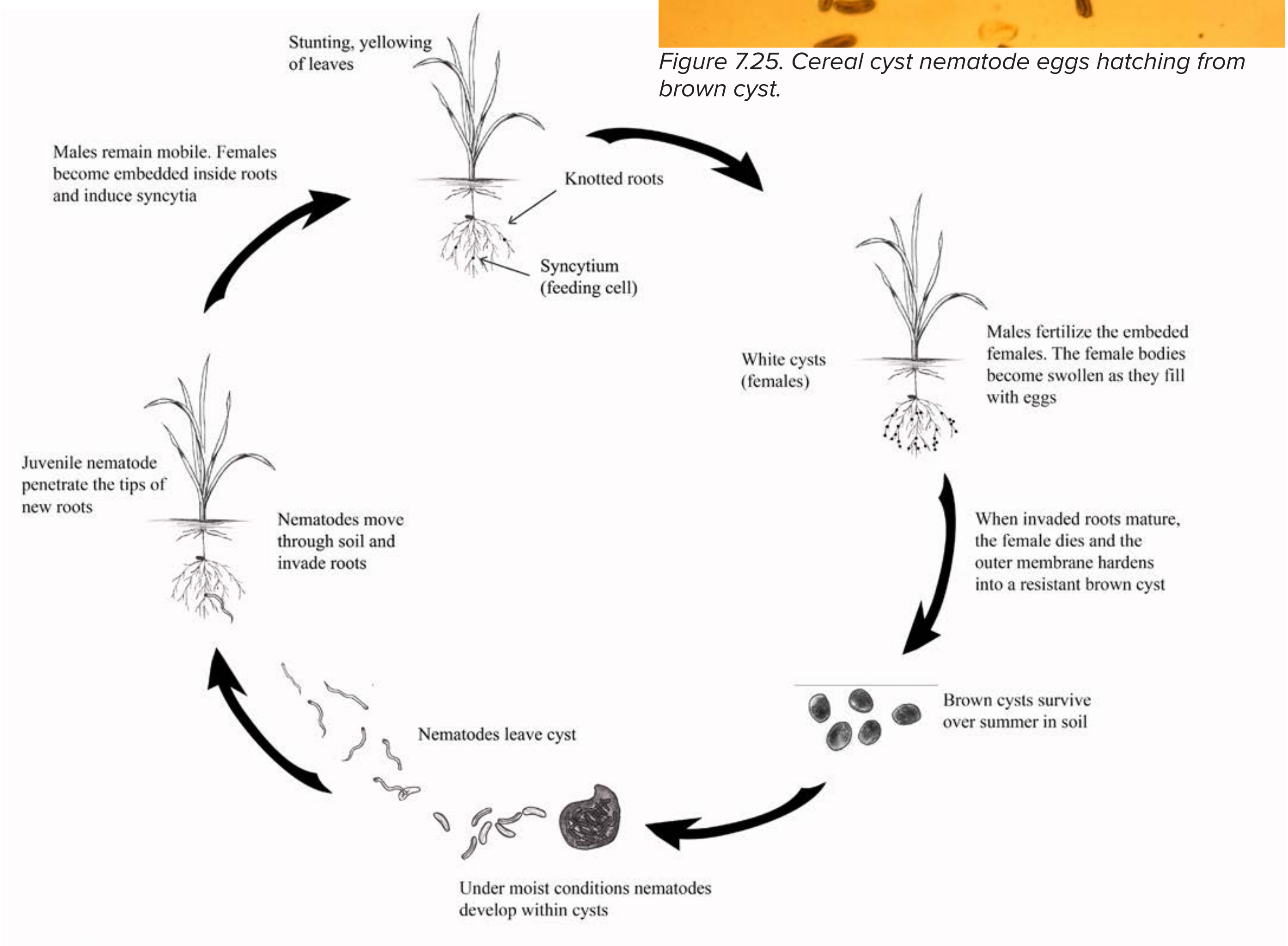


Figure 7.26. Disease cycle of the Cereal cyst nematode. Illustration by Kylie Fowler

PULSE SOIL-BORNE DISEASES PHYTOPHTHORA ROOT ROT OF CHICKPEAS

Phytophthora root rot is a serious constraint to production in northern New South Wales but has been seen regularly in southern Australia over the last few years, particularly when chickpeas are planted under irrigation. It poses a potential threat to chickpea production in wetter regions.

What to Look For

The disease is usually observed late in the season but may also affect young plants. Badly affected seedlings suddenly wither and die with no obvious disease symptoms.

Infected plants are often stunted with obvious yellowing and drying of the foliage. They have few lateral roots and the lower portion of the tap root is often decayed. The remaining tap root is usually discoloured dark brown to black (Figure 7.27). Sometimes the discolouration can extend to the base of the plant. The advancing margins of the lesions may also have a reddish-brown discolouration. The disease can often be mistaken for waterlogging, but with Phytophthora the lower leaves yellow first and have often dropped off unlike waterlogging which affects the whole plant.

Disease Cycle

Phytophthora root rot, a fungal disease caused by the oomycetes *Phytophthora medicaginis*, *P. megasperma*, or *P. drechsleri* survives in soil, plant debris and on other legume hosts including lucerne.

The disease has been severe in fields where previous lucerne stands have been affected by Phytophthora root rot. In wet soils, spores of the fungus are released and attack the developing roots of susceptible plants. If soils remain wet the disease rapidly spreads to other plants (Figure 7.28).

Figure 7.27. Healthy chickpea plant (far left), compared to Phytophthora *infected plants. Note lack of lateral roots and discoloured root tissue*

Management

It is important to avoid soils prone to waterlogging and land where previous lucerne crops were affected by root rot. The incidence and severity of the disease can sometimes be reduced by fungicidal seed treatment. Some varieties have moderate resistance.

Once Phytophthora is identified in a paddock nothing can be done in that season to control the disease or protect the crop. The best control method where the disease is identified is crop rotations by not growing chickpeas or other hosts, and after, monitoring inoculum levels with a soil-borne test. Metalaxyl based seed treatments can provide some level of control, but crop rotations are the best form of control.

Hosts

Phytophthora medicaginis has been observed within chickpea and lucerne crops within Southern Australia with other crops providing a good alternative where the pathogen is present. There is currently limited information on *P. megasperma*, or *P. drechsleri*.

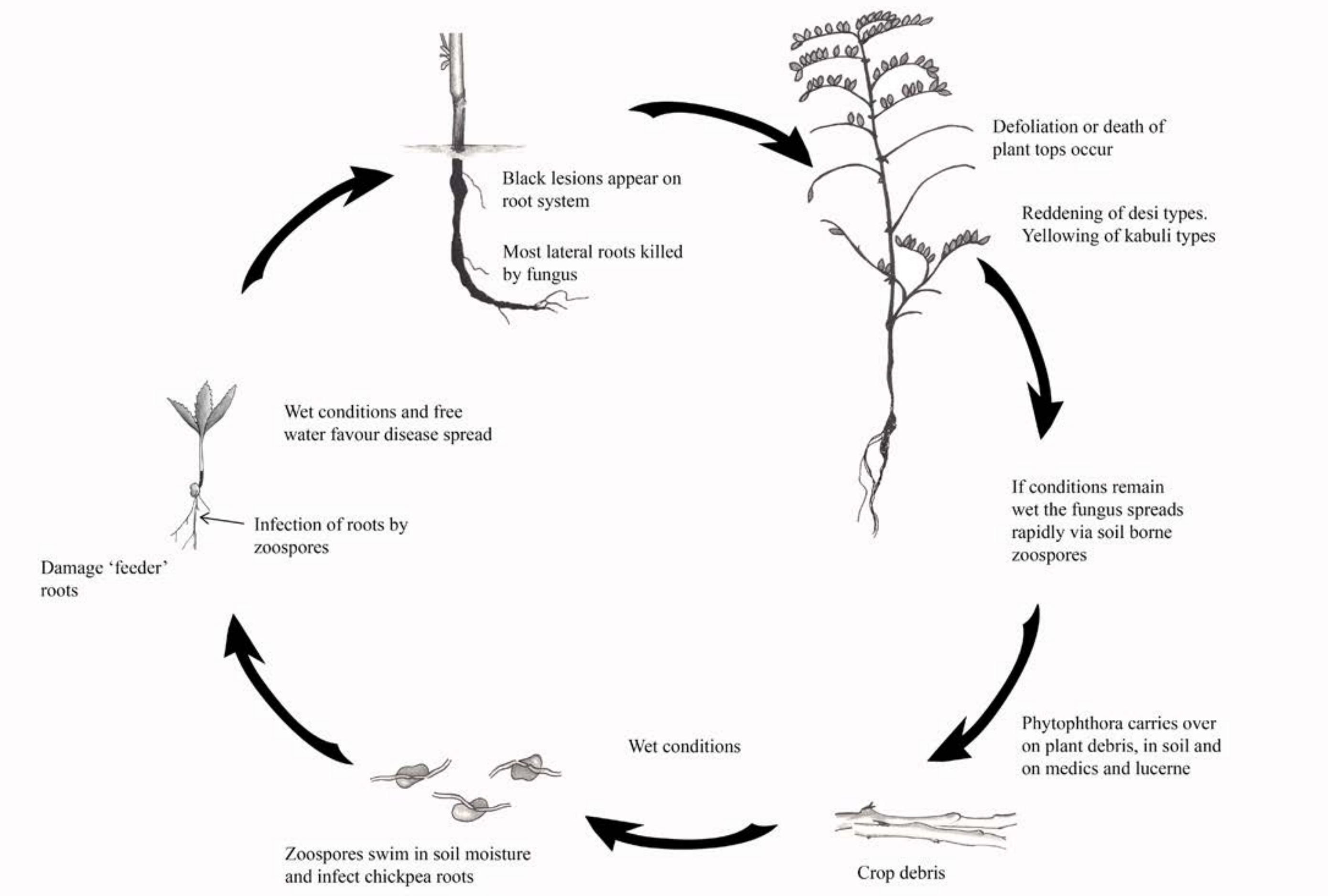


Figure 7.28. Disease cycle of Phytophthora root rot of chickpeas. Illustration by Kylie Fowler

Figure 7.29. Albus lupin plants with symptoms of Phytophthora root rot. Note the rotted root system with a lack of lateral roots. (Photo: Kurt Lindbeck – NSW DPI)

PHYTOPHTHORA ROOT ROT OF LUPINS

This disease was previously known as ‘Lupin Sudden Death’. The causal organism has since been identified as *Phytophthora* spp., hence the change in name to Phytophthora Root Rot. This disease has been seen sporadically in lupin crops in southern New South Wales and parts of Victoria for several years, especially in crops that have been waterlogged in late winter and early spring.

What to Look For

The disease causes sudden wilting and death of lupin plants within days during pod filling. Leaves suddenly turn yellow and drop, often within a 24-hour period. A dark sunken lesion may extend from the base and often up one side of the stem.

Infected plants are found to have a rotted taproot when pulled out of the ground. The taproot is woody in appearance with little if any outer tissue remaining and with few, if any, lateral roots (Figure 7.29).

The pattern of distribution within a crop can vary from single scattered plants to large areas of crop often in low lying areas. Plants fail to fill pods or produce small seed.

Disease Cycle

The fungus survives in the soil and becomes established when a new crop is sown. To date it is not known what other hosts carry this fungal pathogen between lupin crops. However, there appears to be several essential prerequisites for this disease to develop. Soil temperatures must be above 15°C for symptoms to appear. This explains why symptoms in the field do not appear until early spring as soil temperatures rise. A brief period of waterlogging also appears to be required for root infection to occur, hence the occurrence of the disease can be associated with hardpans or perched water tables. Experiments have shown that narrow leafed lupins survive flooding for at least 8 days in the absence of Phytophthora, but die within a short period when the pathogen is present.

In albus lupin, the disease is caused by *Phytophthora cryptogea*, which is also highly pathogenic to lentil. In narrow-leaf lupin, an undescribed species of Phytophthora causes the disease.

To date more work is required to determine the exact cycle of this disease.

Management

Disease management is difficult because of the extended period of survival of the fungus in soil. However, the most effective practice that can be recommended would be to avoid paddocks that are prone to water logging or are known to have a hardpan problem that could result in the formation of perched water tables. Crop rotation is also recommended to avoid the build-up of soil-borne inoculum.

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/crop-variety-guides

NVT website

nvt.grdc.com.au

Root-Lesion Nematodes Tips and Tactics (GRDC)

www.grdc.com.au

http://www.grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

Rhizoctonia Tips and Tactics (GRDC)

https://grdc.com.au/__data/assets/pdf_file/0028/186139/grdc-tips-and-tactics-rhizoctonia-southern-print-version.pdf.pdf

PREDICTA®B

A soil analysis service delivered by accredited agronomists. PREDICTA®B can detect *P. neglectus, P. thornei* and a range of soil-borne diseases. Contact your local agronomist, or to locate your nearest supplier, email your contact details and location to: predictab@saugov.sa.gov.au or visit http://www.pir.sa.gov.au/ research/services/molecular_diagnostics

FOLIAR DISEASES OF CHICKPEA

Authors: Dr Joshua Fanning (Agriculture Victoria) and Dr Kurt Lindbeck (NSW DPI)

ASCOCHYTA BLIGHT OF CHICKPEA

***Note**: Current varieties have limited resistance to ascochyta blight*

Ascochyta blight of chickpea is caused by the fungal pathogen *Ascochyta rabiei* (also known as, *Didymella rabiei* or *Phoma rabiei*) which is specific to chickpea. This is considered to be the most important fungal disease of chickpea worldwide. In 1998 a serious outbreak of the disease occurred in Victoria, South Australia and New South Wales which destroyed many crops. As a consequence the area sown to chickpea fell significantly. Since then, resistant varieties had been released and chickpea production was increasing. During 2016, a further breakdown of resistance occurred in Victoria and since then it has spread across Eastern Australia and resulted in all varieties being rated as Moderately Susceptible to Very Susceptible.

Figure 8.1. Typical first signs of Ascochyta blight symptoms, prior to the development of small dark specks (pycnidia) (Photo: Joshua Fanning – Agriculture Victoria)

Breeding and pre-breeding lines currently under evaluation are showing a more resistant reaction to ascochyta, however, until more resistance is available to growers, fungicides will play an important role in ascochyta management.

Figure 8.2. Typical leaf lesions caused by Ascochyta blight. These are seen as round spots with brown margins. Small dark specks (pycnidia) are often present

Figure 8.3. Typical stem lesions caused by Ascochyta infection, leading to stem breakages (Photo: Joshua Fanning – Agriculture Victoria)

Figure 8.4. Ascochyta blight patches occur within a crop as the disease spreads from infected plants to surrounding healthy plants through rainsplash.

What to Look For

All above ground parts of chickpea plants can be affected by Ascochyta blight. Symptoms can appear on plants at any growth stage, with infection looking more severe when plants are smaller. The disease appears as spot-like lesions which are initially light grey (Figure 8.1) and then develop a tan to dark brown margin and small black dots in the lesion (pycnidia) (Figure 8.2). If these lesions occur on the stem, the lesion constricts the stem, causing girdling, and eventually causes stem breakage (Figure 8.3). The disease spreads during rainfall events in spring from infected plants to surrounding plants by rain splash of spores. If there is limited disease control, obvious symptoms will be visible, particularly in late winter when small patches of blighted plants will be visible throughout the paddock (Figure 8.4). In severe cases the entire plant dries up quickly. Regrowth may occur, but the spores and disease risk are still in the paddock.

Figure 8.5. Typical symptoms of pod infection caused by chickpea Ascochyta blight which often leads to seed infection. (Photo: Joshua Fanning – Agriculture Victoria)

All pods are susceptible to Ascochyta blight and if the disease is already present in the crop and rainfall occurs during podding, lesions are likely to occur on pods. The infection of pods often has similar symptoms to leaf lesions, although the lesions may be darker. Pycnidia will most likely still be visible (Figure 8.5). The fungus can penetrate the pod and infect the seed causing lesions on the seed (Figure 8.6).

When infected seeds are sown, the emerging seedlings will develop dark brown lesions at the base of the stem. Affected seedlings may collapse and die.

Disease Cycle

This fungal disease has an asexual (non-sexual) and sexual stage; the asexual stage occurs in Australia, whilst the sexual stage has not been found in Australia. The fungus survives on infected seed and on old chickpea trash. Sowing infected seed will give rise to infected seedlings that initiate infection within crops. The pathogen can also be carried into new season crops on wind-blown chickpea trash, which can spread the pathogen when it comes into contact with seedlings. Infection can occur at any stage of plant growth provided conditions are favourable. Moisture is essential for infection to occur. During wet weather, the disease can spread further as spores of the fungus are carried onto neighbouring plants by wind and rain splash (Figure 8.7).

Management

Management of Ascochyta blight requires a combination of farm hygiene, variety resistance, crop monitoring and the use of fungicides. An integrated disease management strategy is essential to reduce the grain yield losses caused by Ascochyta blight.

Clean Seed

It is essential to sown clean seed. Sowing old or damaged seed can reduce seedling vigour and increase susceptibility to infection. In addition to re-infection through seed, reduced plant establishment occurs by planting infected seed.

Resistant Varieties

Sow varieties with the greatest resistance. Please note, the Ascochyta blight pathogen population has evolved in recent years. This has resulted in changes in pathogenicity and has decreased the level of resistance in current chickpea varieties. Please check current sowing guides for the latest disease resistance ratings in your region.

Paddock Selection

Infected crop residues harbour *Ascochyta rabiei*. Therefore, avoid planting this season's crop near old chickpea stubble, with at least 500m between crops being preferable. A program of stubble reduction may also be undertaken by grazing or burying to reduce the carry-over of infected stubble into the following season. Allow a break of at least 3 years between chickpea crops.

Seed Treatment

Use a registered seed treatment for the control of Ascochyta blight of chickpea. Seed treatments reduce the chance of seed transmission and provide early seedling protection. Seed treatments can have a deleterious effect on rhizobia. Therefore, seed should be treated with fungicide and then inoculated with rhizobia in two separate operations. Rhizobia should be applied to seed immediately before sowing, especially on acid soils.

Agronomy

Sowing chickpeas between standing cereal stubble has shown to reduce disease severity and subsequent grain yield losses. Experimental results at Horsham showed a susceptible variety has a similar disease severity to a moderately susceptible variety when grown between standing stubble rows as compared to slashed stubble rows.

Sowing

Early sowing encourages early infection and increased levels of the disease. Follow the recommended sowing dates for your district.

Foliar Fungicides

A resistant variety will only need a fungicide at podding to protect seed quality.

Varieties rated MRMS or more susceptible will require varying levels of fungicides to control Ascochyta blight depending on the environment and season. In some seasons, varieties rated Susceptible may need between 4 and 8 fungicides, depending on the number of rainfall events.

In moderately susceptible varieties (the best currently available), the first fungicide is required at the 4-6 node stage if rain is predicted. Depending on subsequent rainfall and the fungicides applied, subsequent application may be required every 2-4 weeks after.

Figure 8.6. A comparison of normal (clean) chickpea seed and seed infected with Ascochyta blight showing typical lesions (Photo: Joshua Fanning – Agriculture Victoria)

More recently released dual active fungicides have been shown to be very effective and will require less applications in a season. See the latest data for recommendations.

All varieties are susceptible to pod infection and will require protection during podding to prevent seed staining and abortion.

Note: *Some fungicides only protect the plant parts which come in contact with the spray, subsequent plant growth will not be protected. Fungicides should be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.*

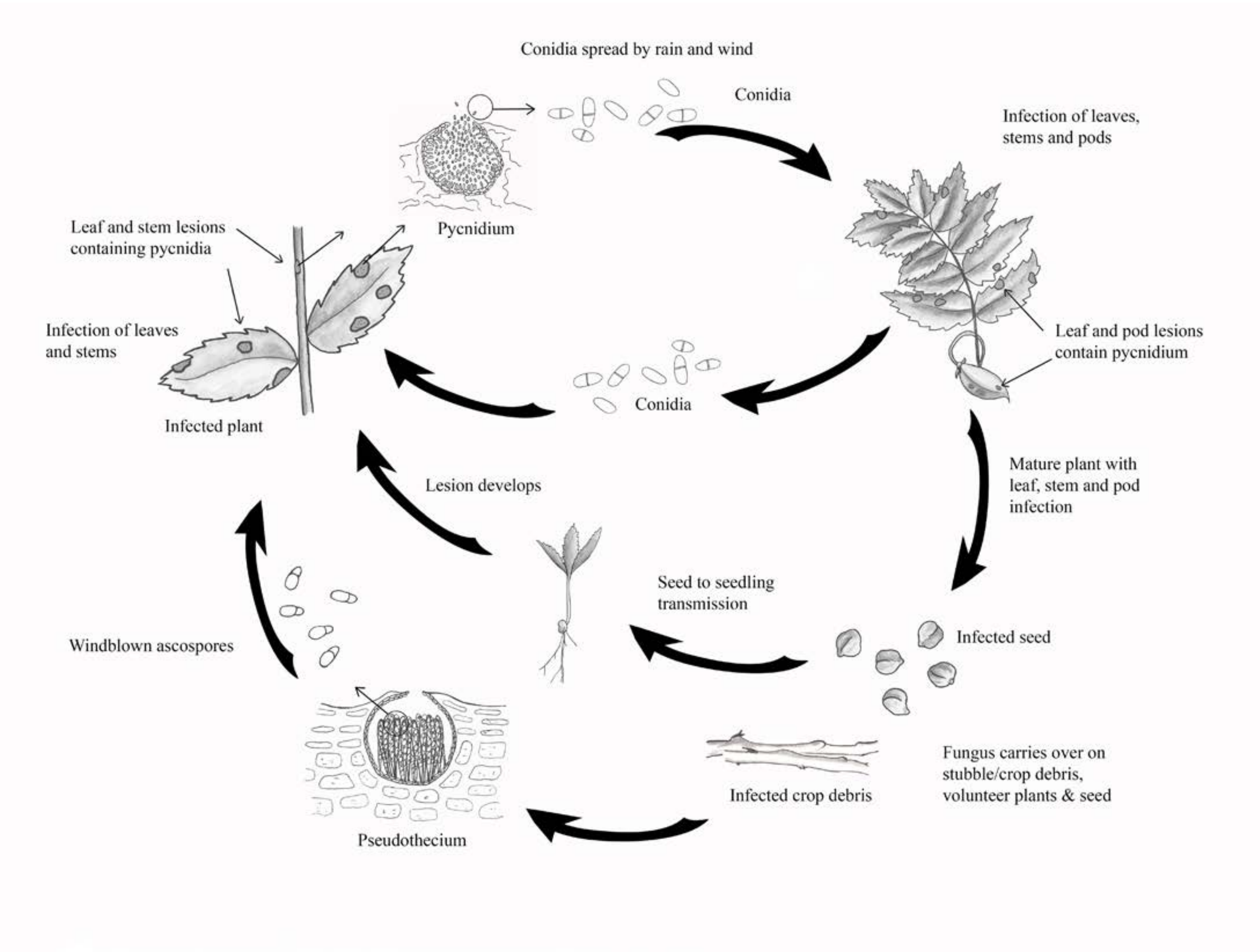


Figure 8.7. Disease cycle of Phoma rabiei *(formerly known as* Ascochyta rabiei*). Illustration by Kylie Fowler*

BOTRYTIS GREY MOULD OF CHICKPEA

Botrytis grey mould (BGM) is caused by the fungus *Botrytis cinerea* and is the second most important disease of chickpea and can infect plants at any stage of development. Under favourable conditions, the disease can develop rapidly, spread widely and cause complete yield loss. Chickpea genotypes with vigorous seedling growth, early canopy closure and early flowering are more likely to develop disease than other varieties. Use of badly infected seed can result in total crop failure where seed is not dressed with a fungicide. Crop losses are greatest in seasons with a wet spring, particularly when crops develop very dense canopies.

What to Look For

Plants may be attacked at any growth stage. Botrytis grey mould is most likely to first appear as a soft rot at the base of the stem in the collar region. The affected tissues become covered with a fluffy grey mould initially (Figures 8.8-8.10).

As the disease progresses affected plants wither and die. Small black sclerotia may form on the surface of affected tissue when the plant dies. Occasionally in older plants, only a few branches on a plant are affected and the rest of the plant appears quite normal. Seedling infection can cause seedling blight and reduce plant establishment.

Figure 8.9. Pod infection caused by botrytis

Disease Cycle

The fungus survives on infected seed, as a saprophyte on decaying plant debris and as soil-borne sclerotia. The disease is often established in new areas by sowing infected seeds (Figure 8.10).

Masses of spores are produced on infected plants. These fungal spores can be carried from plant to plant by air currents and spread the disease rapidly (Figure 8.11). Once a crop has become established, the warm, humid conditions under the crop canopy provide ideal conditions for infection and spread of the disease.

Figure 8.8. Stem infection caused by botrytis. Note fluffy, grey spore mass covering lesion

Figure 8.10. Seed discolouration caused by botrytis infection

Management

Clean Seed

Only use seed low to no known infection of botrytis. Using old or damaged seed can reduce seedling vigour and increase susceptibility to infection.

Seed Treatment

Use a registered seed treatment for the control of seed-borne diseases of chickpea. Seed treatments can have a deleterious effect on rhizobia. Therefore, seed should be treated with fungicide and then inoculated with rhizobia in two separate operations. Rhizobia should be applied to seed immediately before sowing, especially on acid soils.

Paddock Selection

Avoid planting this season's crop near old lentil, faba bean, chickpea, vetch or lathyrus stubbles. These crop residues can harbour *Botrytis cinerea*. A program of stubble reduction may also be undertaken by grazing or burying to reduce the carryover of infected stubble into the following season. Allow a break of at least 3 years between stubbles to reduce the chance of inoculum carryover.

Sowing

Sowing later and reducing seeding rates will lower disease risk. Early sowing and high sowing rates can cause higher biomass and increase the chance of lodging and therefore increases the risk of BGM. Follow the recommended sowing rates and sowing dates for your district.

Foliar Fungicides

In areas of high risk, it may be necessary to apply foliar fungicides to protect the crop. Fungicides should be applied before canopy closure for best results. If conducive (warm and wet) conditions continue, follow up sprays may be necessary, particularly in susceptible varieties.

There are a range of fungicides available to control BGM and selection of the most appropriate fungicide could depend on the level of disease pressure present. It is worth noting that some fungicides are protectants and are most effective if applied before disease development.

Note: *Fungicides should be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.*

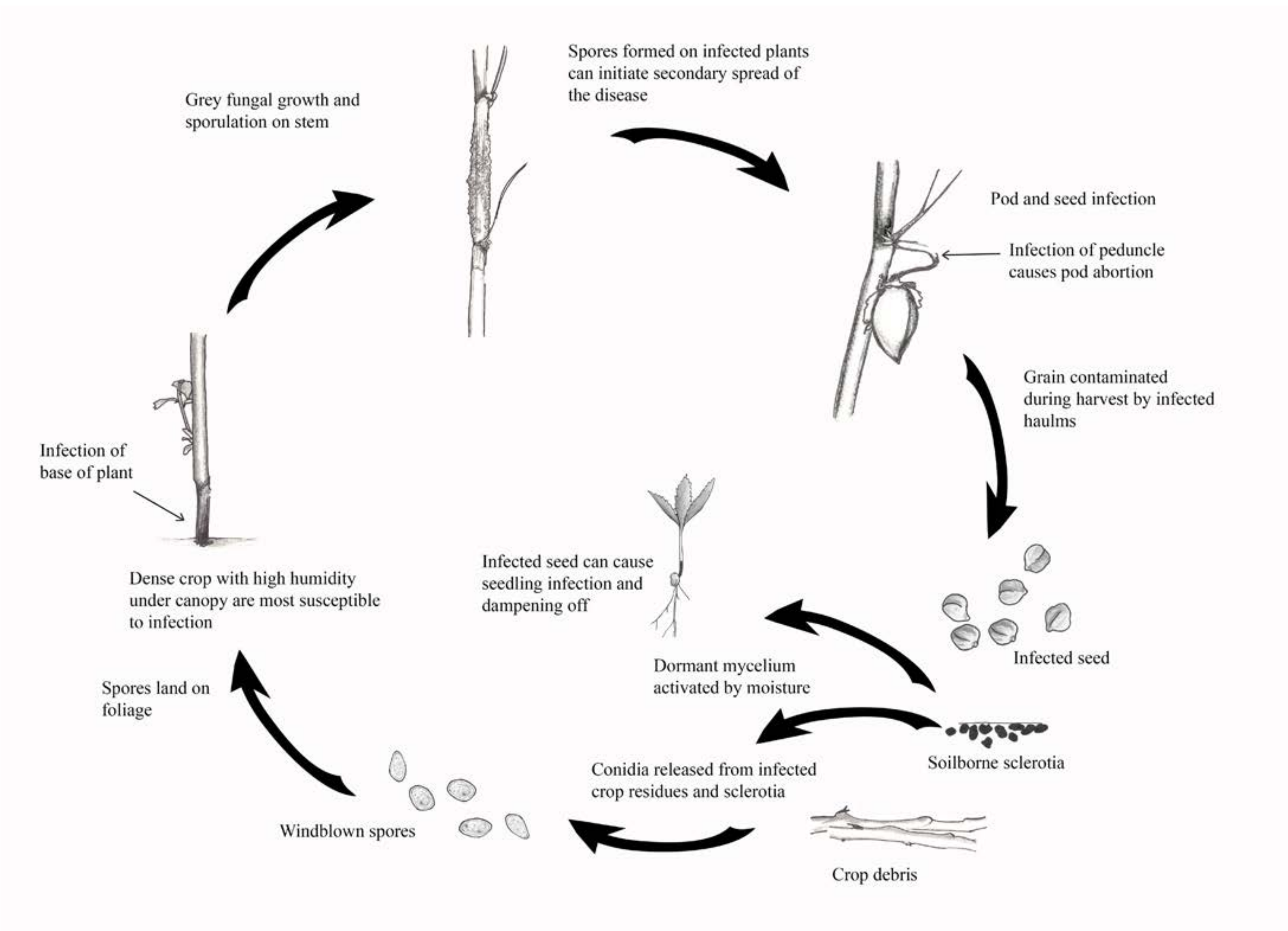


Figure 8.11. Disease cycle of botrytis grey mould in chickpeas. Illustration by Kylie Fowler

SCLEROTINIA ROT OF CHICKPEA

Sclerotinia rot, caused by *Sclerotinia sclerotiorum* and *S. trifoliorum*, is an occasional disease of chickpea but has caused significant crop losses in eastern Australia. Sclerotinia rot can cause serious crop losses where a substantial number of plants within a crop are affected. Kabuli chickpeas appear more susceptible to this disease than desi chickpeas but both types can be seriously damaged under favourable conditions. Dense crops are likely to be the most severely affected, particularly under moist conditions. Grain quality can be decreased when infected with Sclerotinia, which causes poor colour and shrivelled seed.

What to Look For

A small number of dead plants scattered throughout a paddock. Affected plants first wilt and rapidly die, often without turning yellow. Later, as the plant dries out the leaves turn a straw colour.

On the surface of the root, just below ground level, small black fungal bodies called sclerotia (which are irregular in size and shape), can sometimes be seen mingled with white cottony fungal mycelium.

In spring, water-soaked spots may appear on the stems and leaves. Affected tissues develop a slimy soft rot from which droplets of a brown liquid may exude. Infected tissues then dry out and may become covered with a web of white mycelium of the fungus (Figures 8.12-8.14).

Disease Cycle

The disease is usually established from sclerotia (survival bodies of the fungus) present in the soil or introduced with contaminated seed. Outbreaks are more common when very wet conditions occur in late June and early July.

The sclerotia germinate in moist soil and either directly infect roots or produce air-borne spores which attack the above ground parts of the plant (Figure 8.15). Once established, the fungus rapidly moves to adjacent healthy tissue. Within a few days of infection, plants start to wither then die.

Sclerotia formed on infected plants enable the fungus to survive to the following year. Individual seeds can be contaminated with the fungus and/or sclerotia may be present in the seed sample. Sclerotia can remain viable in the soil for up to eight years.

Figure 8.12. Early symptoms of stem infection by Sclerotinia. White mycelial growth starting to develop

Soil-borne sclerotia are the most important disease source for establishing disease in following crops. Seeds infected with sclerotinia can be the cause of disease establishment in otherwise sclerotinia-free areas.

Management

Clean Seed

The seed harvested from infected crops should not be used for sowing. Use of disease-free seed minimises the risk of disease and prevents it being established in a new area. It is important to avoid sowing chickpeas in areas where the disease is known to be present.

Paddock Selection

Crop rotation is the best method of control once the disease has become established. Cereal crops are not affected by sclerotinia and provide a good disease break. Pulse crops, oilseeds (canola), legume-based pastures and capeweed are all good hosts for the pathogen (Table 8.1).

If a sclerotinia rot problem does occur, a four-year break from disease hosts is required to substantially reduce the number of sclerotia in the soil. The most practical option is to use cereals and other legumes which are more resistant to sclerotinia than chickpea.

Figure 8.13. Comparison of stem infections caused by Sclerotinia (left) and botrytis (right). Note different colour of the fungal growth

Figure 8.14. Sclerotinia stem infection of chickpeas. White fluffy mycelium and sclerotia formation are evident

Seed Treatment

No commercial seed treatments are known to control this disease in crop.

Sowing

Sow within the recommended sowing window for your district. Early sown chickpea crops are more prone to developing sclerotinia rot.

Foliar Fungicides

Some recently registered fungicides are registered for control of sclerotinia in pulse crops. *Fungicides should be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.*

Table 8.1. Effects of Sclerotinia on crops

CROP	SCLEROTINIA	
	Potential Severity of Disease on Crop	Disease Host
Wheat	None	No
Barley	None	No
Oats	None	No
Canola	Moderate-Severe	Yes
Safflower	Moderate	Yes
Sunflower	Severe	Yes
Linola	Moderate	Yes
Field pea	Minor	Yes
Chickpea	Moderate-Severe	Yes
Faba bean	Minor	Yes
Lupin	Moderate-Severe	Yes
Lentil	Moderate	Yes
Vetch	Minor	Yes
Legume pasture	Minor	Yes

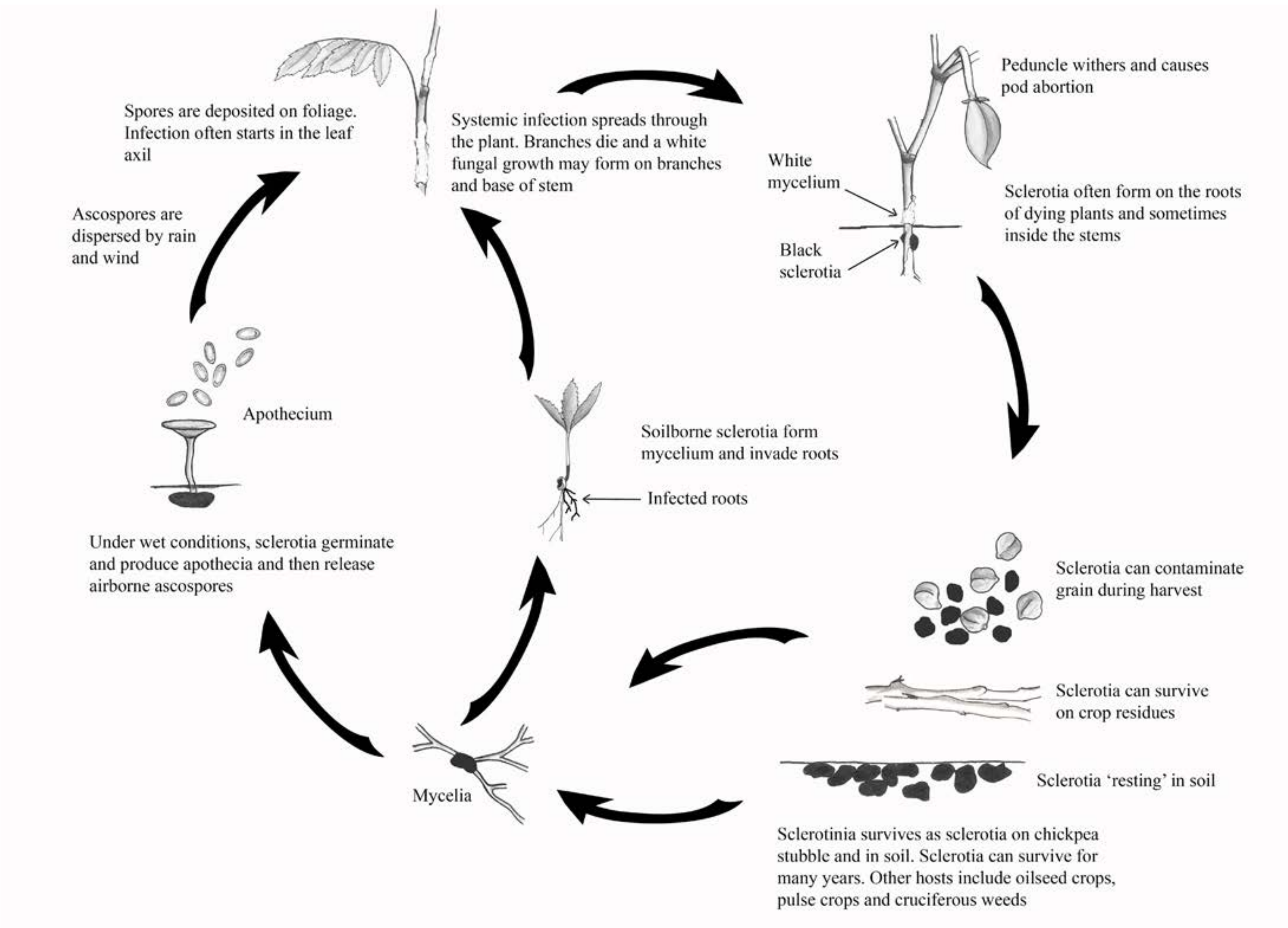


Figure 8.15. Disease cycle of Sclerotinia of chickpea. Illustration by Kylie Fowler

PHOMA BLIGHT OF CHICKPEA

Phoma blight, caused by the fungus *Phoma medicaginis* var. *pinodella*, has the potential to be a serious disease of chickpeas. The disease has only caused serious crop losses in seasons with above average winter rainfall.

What to Look For

Seed-borne infection often results in black-brown discolouration of the root near the point of seed attachment (Figure 8.16). Blackening may spread up the root and cause lesions at the base of the stem.

Initial above ground symptoms are small, dark tan coloured, irregular flecks on leaves, stems and pods. The flecks on leaves enlarge to lesions and the surrounding tissue yellows. Within the lesions numerous pinhead-sized black fruiting bodies of the fungus develop. Similar but more elongated lesions form on the stem.

Black lesions may completely girdle the base of the stem and roots where infection is severe (Figure 8.17). Pod lesions are sunken, with pale centres and dark margins and may be covered by small black spots. The fungus may penetrate the pod and infect developing seeds. Badly affected plants may be totally defoliated when infected leaflets senesce and fall.

Figure 8.17. Collar rot symptoms caused by phoma

Disease Cycle

The fungus can survive on infected seed, in soil and on crop residue (Figure 8.18). Outbreaks of the disease are most likely to be in those paddocks with a recent history of chickpea or field pea. Infected seeds may give rise to infected plants, or spores in the soil may infect the roots of young plants. Spores produced on infected crop residues may also be carried by wind into the new season's crop. Infection can occur at any stage of plant growth provided conditions are favourable.

Moisture is essential for infection to occur.

During wet weather, the disease may spread further when fungal spores are carried by wind and rain-splash onto neighbouring plants. Severe pod infection results in reduced yield and infected seed. However, grain quality (i.e. appearance and grain size) is not affected.

Management

Clean Seed

The use of disease free seed and crop rotation will help prevent the establishment and build-up of this disease.

Paddock Selection

Where chickpeas have been badly infected, a two-year break from host crops will minimise the disease risk. Crops which host phoma include field pea, chickpea, faba bean, lupin, lentil, vetch and legume pasture species. Cereal and oilseed crops will provide a good disease break.

Figure 8.16. Typical Phoma lesions at the base of the stem

Fungicides

Seed-borne disease infection can sometimes be controlled with fungicide seed dressings. No fungicides are known to manage this disease in crop.

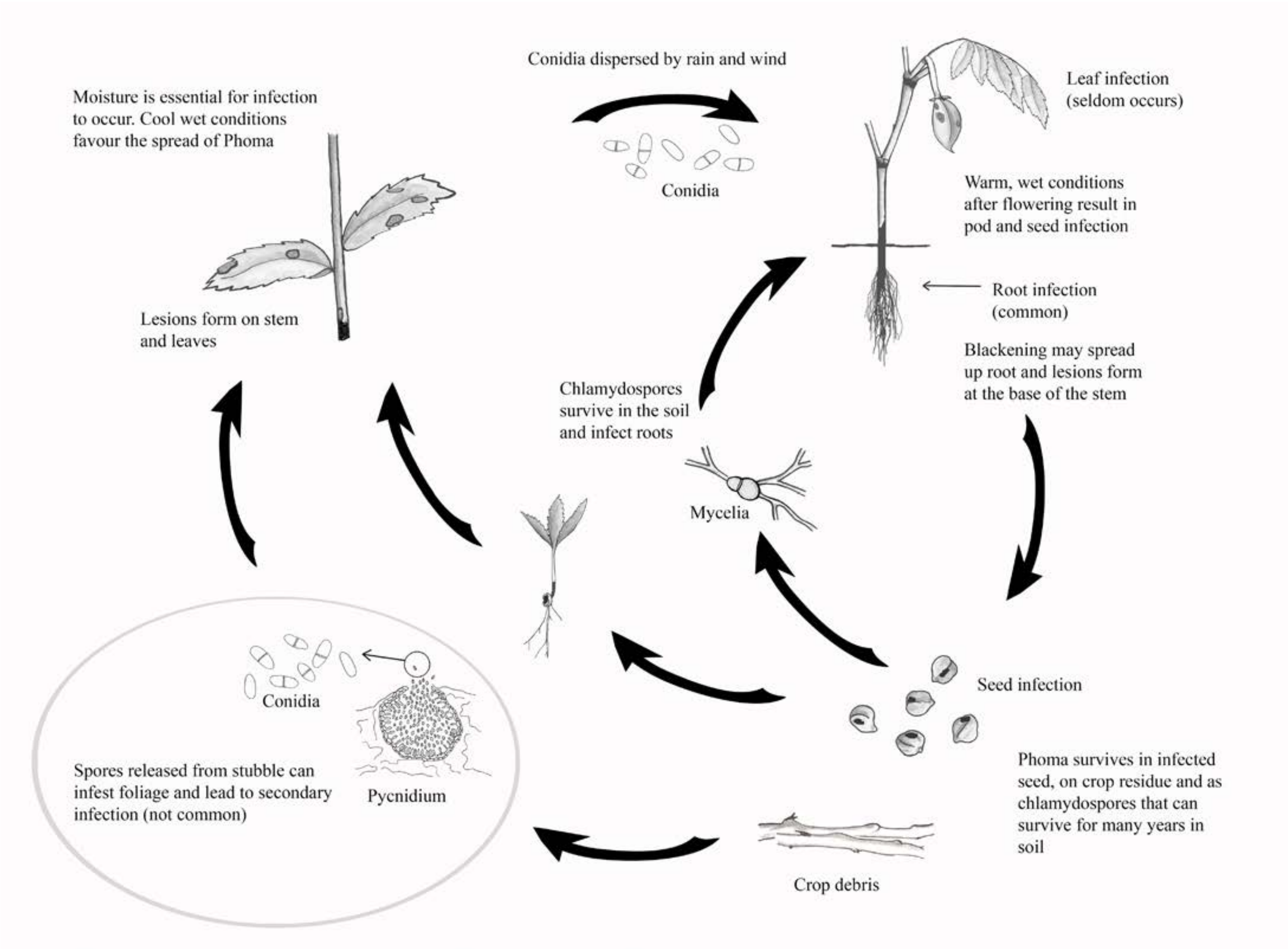


Figure 8.18. Disease cycle of phoma stem rot of chickpeas. Illustration by Kylie Fowler

Table 8.2. Chickpea disease guide summary

DISEASE	ORGANISMS	SYMPTOMS	OCCURRENCE	HOSTS	CONTROL
Ascochyta blight	*Ascochyta rabiei* (also known as, *Didymella rabiei* or *Phoma rabiei*)	Pale brown lesions on leaves, stems and pods. Lesions may have a grey centre containing small black specks which are the fruiting bodies. Infected stems wither and break	Most severe in spring, likely to effect all chickpea crops	Chickpea, most pulses, including lentil and faba bean	Avoid susceptible varieties, seed dressing, rotation, foliar fungicides
Botrytis grey mould	*Botrytis cinerea*	Poor emergence and death of young plants. Soft rot at the base of the stem. Grey mould growth on leaves, stems and pods. Lodging of plants in dense crops. Discolouration of seed with grey/ black mould	Most severe in wet seasons. Dense crops are more likely to be affected than thin crops	Most pulses, oilseeds and broadleaf weeds	Seed dressings, lower plant densities, avoid early sowing
Sclerotinia	*Sclerotinia sclerotiorum* and *S. trifoliorum*	Scattered dead plants within a crop. Cottony white fungal growth on the lower stems of dead plants. Soft rot and white mould on stems and pods	Most severe in wet seasons where chickpea is planted in fields recently cropped to chickpea	Chickpea, most pulses	Crop rotation, fungicides
Damping off (refer to chapter seven)	*Pythium* spp.	Poor crop establishment under wet conditions. Seed rotting in the ground. Sudden death of young seedlings	In soils that become very wet just after sowing. More severe on kabuli than desi chickpea	Kabuli chickpea, most pulses	Seed dressings, avoid poorly drained soils
Phytophthora (refer to chapter seven)	*Phytophthora megasperma*	Plants suddenly wither and die, particularly after water logging. Dark brown to black discolouration of the tap root	May be a problem in poorly drained soils under wet conditions	Chickpea, lucerne	Resistant varieties
Phoma blight	*Phoma medicaginis*	Blackening of the stem near ground level. Dark, tan coloured lesions on leaves, stems and pods	Common in most chickpea growing regions. Most severe in wet seasons	Most legumes	Crop rotations
Root lesion nematode (refer to chapter 6)	*Pratylenchus thornei* and *Pratylenchus neglectus*	Ill-thrift, lack of branching of root system, small dark stripes on roots	Favoured by wheat in rotation with chickpea, medic and vetch	Wheat, chickpea, medic, vetch, narbon bean	Crop rotation (predictive soil test available)
Alfalfa mosaic virus	Virus	Tip necrosis	Occurs in all chickpea growing areas		Virus-free seed Resistant varieties
Cucumber mosaic virus	Virus	Yellowing, stunting, offshoots	Prevalent in all chickpea growing areas	Most pulses, pastures, horticultural, crops, and weeds	Virus-free seed Resistant varieties
Beet western yellows virus	Virus	Yellowing, stunting, offshoots	Occurs in all chickpea growing areas	Most pulses, brassicas and weeds	Managing aphids and weeds, resistant varieties

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/ plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/ crop-variety-guides

NVT website

nvt.grdc.com.au

Seed Health Testing in Pulse Crops

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/ plant-diseases/grains-pulses-and-cereals/seed- health-testing-in-pulse-crops

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf

Pulse Australia

www.pulseaus.com.au

FOLIAR DISEASES OF FABA BEANS

Authors: Dr Joshua Fanning (Agriculture Victoria) and Dr Kurt Lindbeck (NSW DPI)

CHOCOLATE SPOT OF FABA BEAN

Chocolate spot, caused by *Botrytis fabae* and *B. cinerea*, is the most severe disease affecting faba beans in Victoria, South Australia and New South Wales. Chocolate spot occurs in all areas where faba beans are grown and can cause complete crop failure. Losses vary based on the severity of infection, the time at which infection occurs and the amount of spring rainfall. Affected plants usually have fewer pods which reduces the yield potential of the crop. In unprotected crops, the disease can be expected to reduce yields by 30-80 per cent when there is favourable disease conditions. In addition, seed from badly affected plants may have a reddish-brown discolouration, which lowers their market value.

What to Look For

Symptoms are varied and range from small discreet spots on the leaves to complete blackening of the entire plant. Leaves are the main plant part affected, but under favourable conditions for the disease it also spreads to stems, flowers and pods.

Two stages of the disease are usually recognised. First, a non-aggressive phase, when discrete reddish-brown spots are 'peppered' over the leaves, flowers and stems (Figures 9.1 to 9.3). Next an aggressive phase occurs when spots darken in colour and coalesce to form larger grey-brown target spots that may eventually cover the entire plant. Small black sclerotia may sometimes be found formed on the surface of infected plant parts including petioles and stems.

Sometimes, red-legged earth mite damage can be mistaken for chocolate spot (Figure 9.4). This starts as silvery patches which become red-brown, similar in colour to chocolate spot but form large, irregularly shaped areas. Red-legged earth mite damage usually occurs during the seedling stage and on the lower leaves.

Figure 9.1. Chocolate spot development on faba bean plant, showing infected leaves (Photo: Joshua Fanning – Agriculture Victoria)

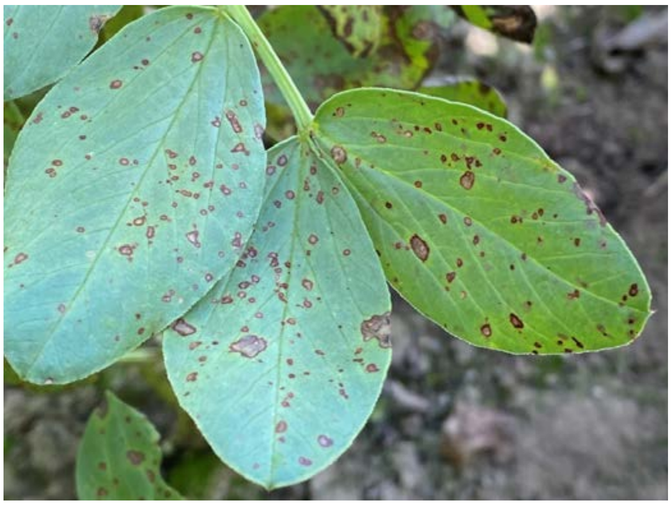


Figure 9.2. Characteristic chocolate spot on leaf of infected faba bean plant (Photo: Joshua Fanning – Agriculture Victoria)

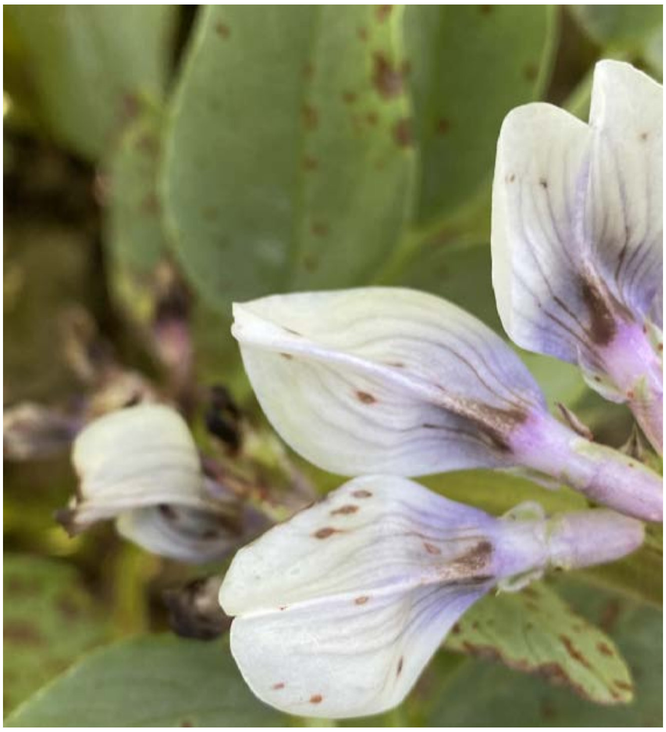


Figure 9.3. Chocolate spot development on faba bean plant, showing infected flowers (Photo: Joshua Fanning – Agriculture Victoria)

Figure 9.4. Red-legged earth mite damage can be mistaken for chocolate spot. Symptoms start as silvery patches which become red-brown. They are similar in colour to chocolate spot but form large irregularly shaped area (Photo: Joshua Fanning – Agriculture Victoria)

Disease Cycle

The pathogens (*Botrytis cinerea* and *B. fabae*) can survive on stubble residue (lentil, vetch, chickpea or faba bean), in the soil as sclerotia or can also be carried on infected seed. The disease inoculum readily survives on alternate hosts such as vetch (*B. cinerea* and *B. fabae*), lentil, (*B. cinerea* and *B. fabae*) and chickpea (*B. cinerea*), which are also grown in close rotation with faba bean. In new bean growing areas the disease often becomes established by sowing infected seed. In subsequent years the initial infection usually occurs when spores formed on old bean stubble are carried by wind into new crops. These spores may move long distances. Once the disease becomes established, it rapidly spreads within a crop and within 4-5 days of infection, spores can be formed on infected tissue and initiate the secondary spread of the disease. The fungus is most aggressive under warm, humid conditions, particularly at flowering time. In spring, hot and dry conditions can retard the disease and stop its spread (Figure 9.5).

Management

An integrated approach is the key to successful management of chocolate spot in faba bean.

Seed Selection

Aim to use the 'cleanest' seed possible with 10 per cent to nil levels of chocolate spot present. Seed should be sourced from the 'cleanest' crops. Old, frosted or damaged seed may have reduced germination and reduced vigour.

Variety Selection

Select the variety with the highest level of resistance to the important disease risk in your district.

Paddock Selection

A break of at least 4 years should be observed between faba bean crops. Aim to separate this year's faba bean crop from last year's faba bean stubble by a distance of 500m. Reduce disease risk by not sowing adjacent to vetch, chickpea or lentil stubble.

Sowing

Increasing plant densities has been shown to increase the risk of chocolate spot. Follow the recommended sowing rates for your district; remember that sowing rates may vary between varieties.

Foliar Fungicides

With all current varieties being rated MRMS to Very Susceptible, fungicides are going to be required in conducive disease conditions occur. A successful fungicide program relies on crop monitoring, correct disease identification and timeliness of spraying with the correct product. Be aware of the critical periods for disease management. A fungicide prior to canopy closure is recommended in most growing districts with crops in higher rainfall districts/seasons requiring follow up applications.

Harvest

Plan to harvest as early as possible, to minimise disease infection on seed.

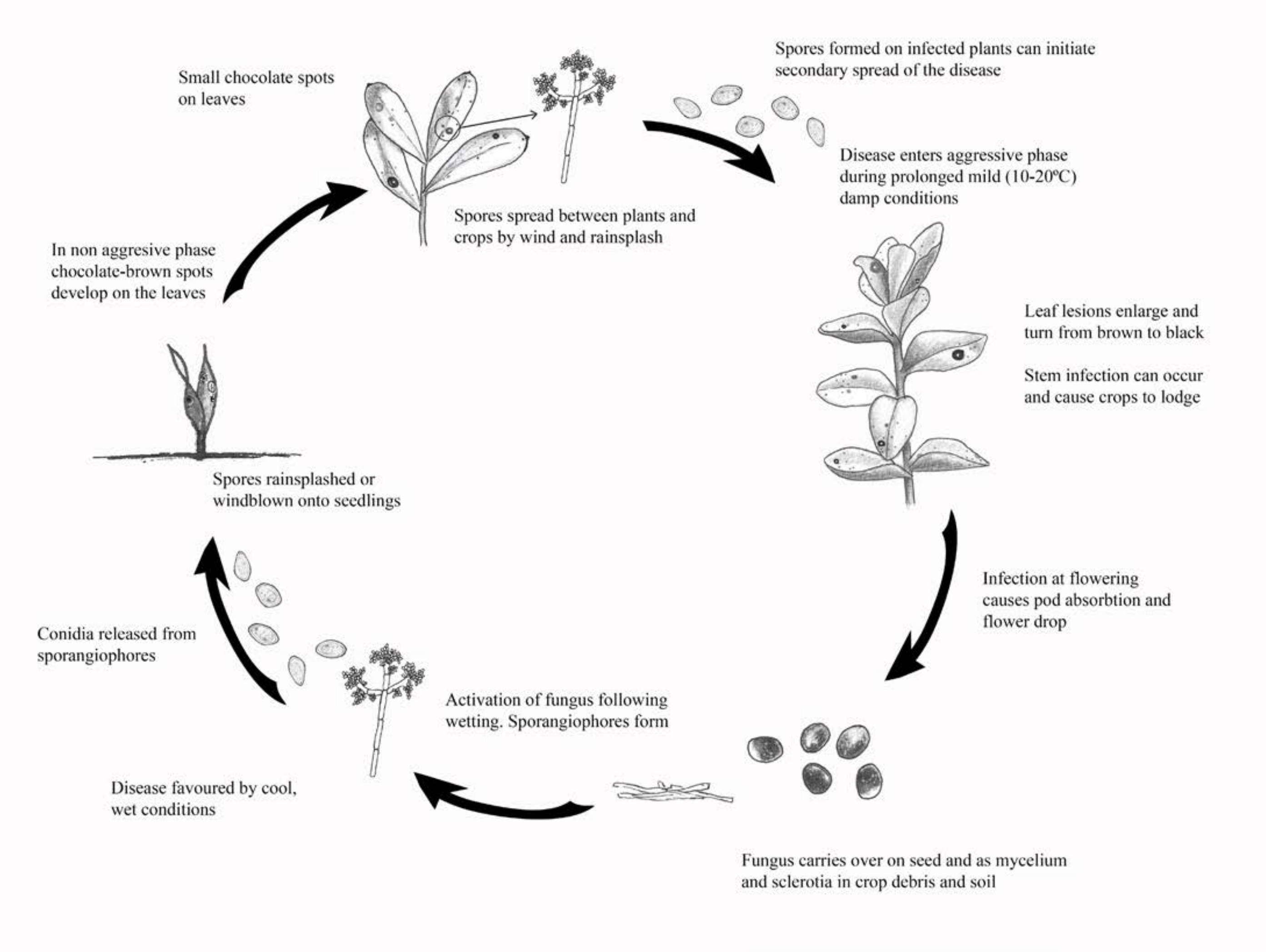


Figure 9.5. Disease cycle of Chocolate Spot on faba bean. Illustration by Kylie Fowler

Figure 9.6. Ascochyta lesions start as small grey spots (Photo: Joshua Fanning – Agriculture Victoria)

Figure 9.7. Often these centres fall out leaving holes in the leaf centres containing black fruiting bodies (Photo: Joshua Fanning – Agriculture Victoria)

ASCOCHYTA BLIGHT OF FABA BEAN

Ascochyta blight, caused by *Ascochyta fabae*, is an important disease of faba beans in Victoria, South Australia and New South Wales. The disease is widespread in southern Australia, but its severity varies considerably from crop to crop and between seasons. Yield losses of 10 - 30 per cent can occur in seasons favourable for the disease.

A shift in virulence for Ascochyta blight found and has resulted in the disease ratings for Ascochyta blight separated into two pathotypes (pathotype 1 and pathotype 2). Both pathotypes are now found across South Australia and Victoria. There are early signs of additional pathotypes developing as resistance breaks down on current varieties.

What to Look For

Lesions can form on leaves, stems and pods of infected plants and may be confused with the early stages of chocolate spot. On both the top and bottom sides of leaves; small, circular, dark brown spots first appear which enlarge and turn light to dark grey in colour as the disease develops (Figures 9.6 and 9.7). They become irregular in shape, often zonate and may coalesce to cover most of the leaf surface. Leaf tissue next to the lesions may become black and necrotic. Within the lesions, numerous pinhead-sized black fruiting bodies (pycnidia) of the fungus develop. Pycnidia are only formed under moist conditions and are often concentrically arranged. On the stem, lesions are more elongated, sunken and darker than leaf lesions and are usually covered with scattered pycnidia.

Stems may split and break at the point of infection causing plants to lodge.

On pods, lesions are sunken, with pale centres and dark margins and may be covered by numerous pycnidia.
Well- developed lesions may penetrate the pod and infect developing seeds causing them to be shrunken and discoloured. Badly infected seeds have yellowish-brown stains on the outer seed coat (Figure 9.9).

Disease Cycle

The causal of Ascochyta blight, *Ascochyta fabae*, can carry over in infected seed or survive on infected stubble from previous diseased crops (Figure 9.8). It is important to keep in mind even with sowing clean seed and a good paddock rotation, *A. fabae* can infect new crops when spores from infected stubble are carried by the wind from old bean paddocks. Infection can occur at any stage of plant growth; however, moisture is essential. The disease is most severe early in the season and in wet years. Cool, wet weather promotes sporulation, spore dispersal and infection. Secondary spread within crops occurs when spores produced on diseased plants are a carried by wind and rain-splash onto neighbouring plants. Heavy rainfall late in the season can cause pod infection and subsequent seed discolouration.

Management

An integrated approach is the key to successful management of Ascochyta blight in faba bean.

Seed Selection

Aim to use the 'cleanest' seed possible with 5 per cent to nil levels of Ascochyta present. Seed should be sourced from the 'cleanest' crops. Old, frosted or damaged seed may have reduced germination and reduced vigour.

Paddock Selection

A break of at least 3 years should be observed between faba bean crops. Aim to separate this year's faba bean crop from last year's faba bean stubble by a distance of 500m.

Variety Selection

Select the variety with the highest level of resistance to the important disease risk in your district. It is important to check the latest resistance ratings as they may change as resistance breaks down. Refer to the latest Victorian Pulse Disease Guide or the GRDC NVT Website for up to date ratings.

Sowing

Follow the recommended sowing rates for your district, remember that rates may vary between varieties. Plan to sow within the optimum sowing window for your district.

Foliar Fungicides

A successful fungicide program relies on crop monitoring, tailoring fungicides to the varietal resistance, correct disease identification and timeliness of spraying with the correct product. Use a registered product and remember many fungicides are protectants and are most effective if applied before disease development.

Fungicides should be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.

Harvest

Plan to harvest as early as possible to minimise disease infection on seed.

Figure 9.9. Faba bean seed discoloured by late infection of Ascochyta blight

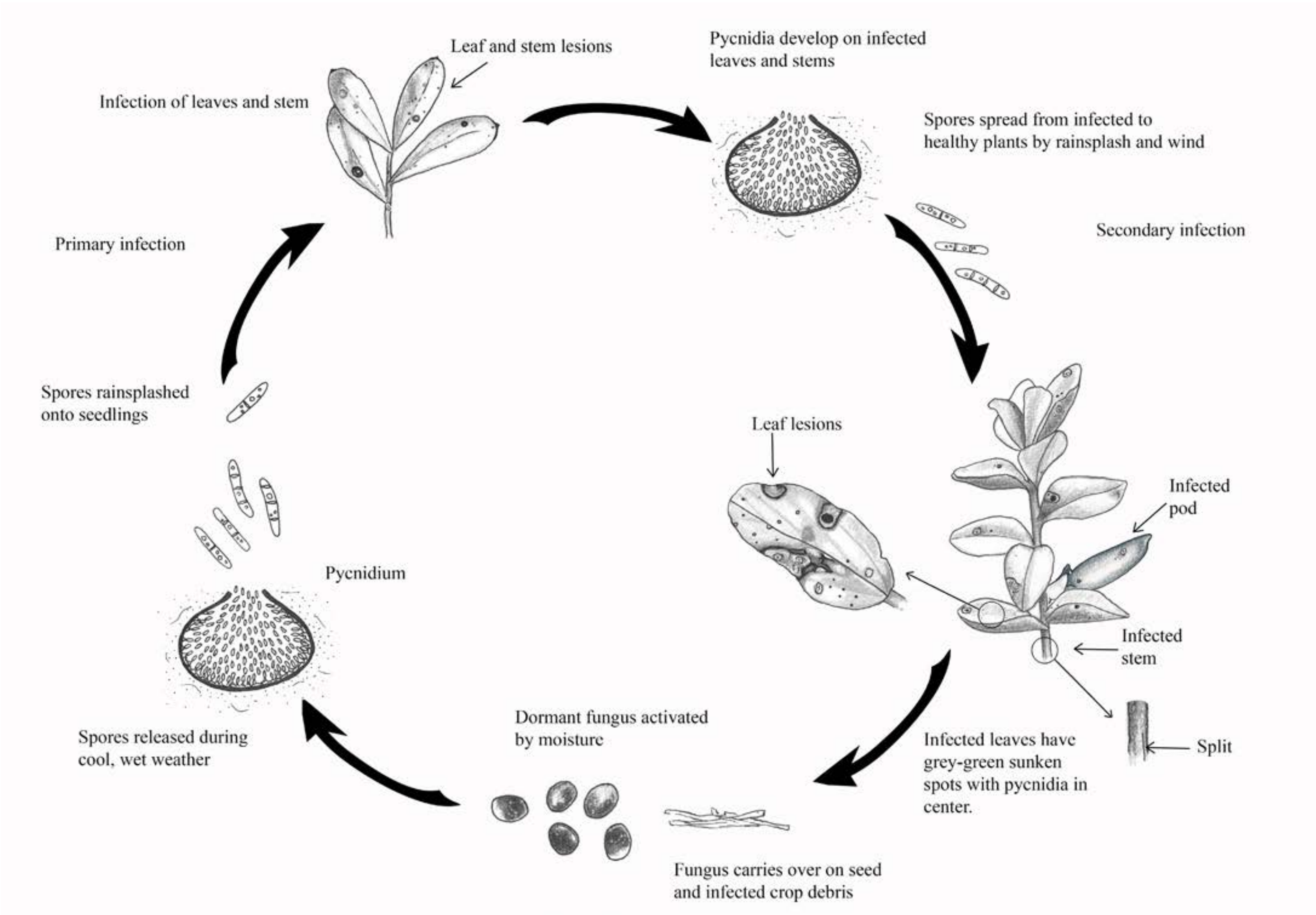


Figure 9.8. Disease cycle of Ascochyta blight on faba bean. Illustration by Kylie Fowler

ALTERNARIA LEAF SPOT OF FABA BEAN

Alternaria leaf spot is caused by the fungal pathogen *Alternaria alternata*. This is a minor disease of faba beans occurring late in the season. The main impact of the disease is confusion with the disease chocolate spot.

What to Look For

Dark brown leaf spots which often have a zoned pattern of concentric brown rings with dark margins (Figure 9.10). Symptoms can be confused with chocolate spot.

Disease Cycle

Alternaria is a weak pathogen of many hosts and is usually a secondary pathogen that only attacks following damage by other fungi or insects. Alternaria leaf spot develops late in the season as the plants start to mature. The fungus probably survives on crop residues and on other hosts.

Management

Control of alternaria alone is usually not warranted.

Figure 9.10. Alternaria lesions have concentric rings within lesions. However no black fruiting bodies are produced as does Ascochyta

CERCOSPORA LEAF SPOT OF FABA BEAN

Cercospora is caused by the fungal pathogen *Cercospora zonata*. This disease can cause problems in some years. The disease often occurs when plants are grown in wet patches, particularly where free water remains on the soil surface. The effect on yield has shown to be in the magnitude of 5-10 per cent under high disease pressure. Early infection by Cercospora can also make crops more susceptible to secondary chocolate spot infection, so it is important to have early disease control.

What to Look For

Cercospora zonata mainly affects leaves, but may also affect stems and pods of faba beans. Lesions initially form on lower leaves of the seedling, early in the growing season, then expand resulting in severe blighting of the leaf. Dark irregular lesions form which may be difficult to distinguish from Ascochyta blight. However, lesions of Cercospora tend to be darker and their shape is more irregular. Within the spots a concentric ring pattern can often be seen (Figure 9.11).

The disease spreads to upper foliage if conditions favour disease development. Severe infection can result in extensive defoliation of plants and lesions on pods.

Disease Cycle

Cercospora originates from soil-borne inoculum and previously infected plant material. It is spread during the season by conidia that dislodge from short white spore clumps on the surface of lesions (Figure 9.12).

Management

Cercospora leaf spot is often confused with Ascochyta blight and chocolate spot. With no varietal resistance, control is through paddock rotations and foliar fungicides.

Paddock Selection

Infected crop residues can harbour *Cercospora zonata*. Therefore, avoid planting this season's crop near old faba bean stubble. Allow a break of at least 3 years between faba bean crops.

Foliar Fungicides

Foliar fungicides are recommended to protect crops, especially in higher rainfall environments where early Cercospora infection can lead to increased risk of chocolate spot infection. Use a registered product around the 4-node growth stage to prevent Cercospora.

Fungicides should be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.

Figure 9.11. Cercospora leaf spots tend to be darker than those of chocolate spot with irregular shaped edges. A ring pattern may also develop. Unlike ascochyta, no pycnidia are produced

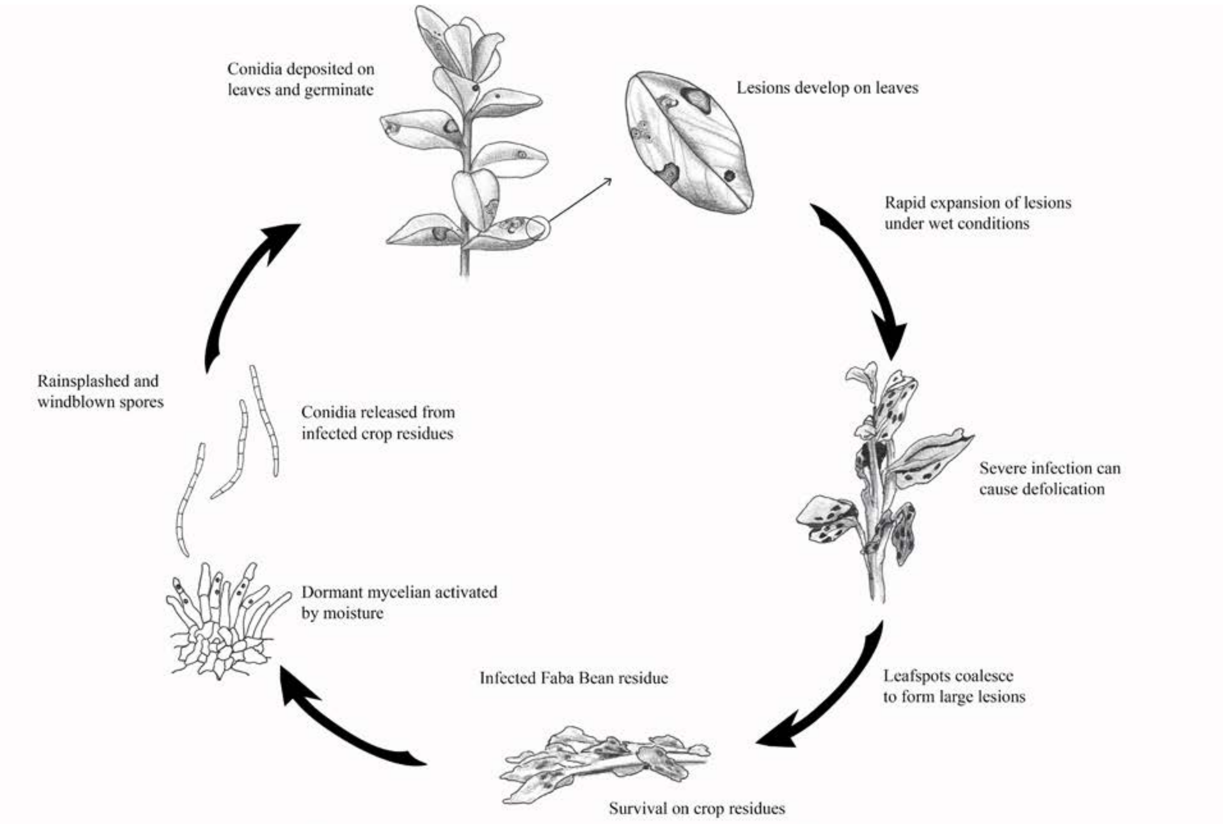


Figure 9.12. Disease cycle of Cercospora on faba beans. Illustration by Kylie Fowler

RUST OF FABA BEAN

Rust, caused by the pathogen *Uromyces viciae-fabae*, is a serious disease of faba beans in northern New South Wales and sporadically occurs in Victoria and South Australia. Rust epidemics can significantly reduce faba bean yields. Alone the disease has caused losses of up to 30 per cent, while, (in combination with chocolate spot), yield reductions of up to 50 per cent have been reported.

What to Look For

On the leaves there are numerous small, orange-brown pustules each surrounded by a light-yellow halo (Figures 9.13, 9.14, 9.15). As the disease develops, severely infected leaves wither and may fall from the plant.

On stems, the rust pustules are similar, but often larger, than those on the leaves. Isolated rust pustules may appear on the pods. Severe infection may cause premature defoliation, resulting in reduced seed size.

Disease Cycle

The rust fungus survives on stubble and self-sown volunteer bean plants. The teliospores produced can infect volunteer bean plants directly without the need for an alternate host. Infection of volunteer faba bean plants is thought to be an important factor in the early development of rust epidemics. Rust spores from stubble and volunteers are blown onto new crops by the wind and infect plants.

Figure 9.13. Infection by rust produces orange / brown pustules on leaves. Spores are easily dislodged by wiping with your finger

Figure 9.14. Rust (left), Ascochyta (centre) and Chocolate spot (right)

New spores form in rust pustules on infected plants. Secondary spread of the disease occurs when these spores become air-borne and then spread to other plants (Figure 9.16).

Rust commonly occurs late in the growing season during podding, resulting in premature leaf drop which can reduce seed weight and size. Humid and warm conditions (more than 20°C) promote disease spread.

Management

Because spores of the fungus can travel long distances to infect a new crop, prevention is difficult.

Paddock Selection

A break of at least three years between faba bean crops is recommended. Aim for a separation of 250m from the previous year's faba bean paddock. Do not sow adjacent to last year's faba bean stubble.

Variety Selection

A number of faba bean varieties are currently available with improved resistance to rust.

Foliar Fungicides

Foliar fungicides can be used to control the disease and prevent a rust epidemic developing. Crops should be monitored closely if warm (approx 20°C) temperatures and very high humidity occur. Successful fungicide application relies on crop monitoring and timeliness of application with the right product effective against rust. Several products are registered for use against rust.

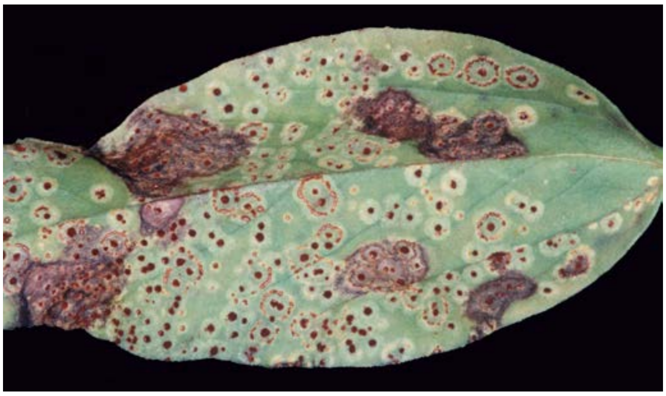


Figure 9.15. Leaf symptoms of teliospores of the rust fungus established on mature faba bean leaf

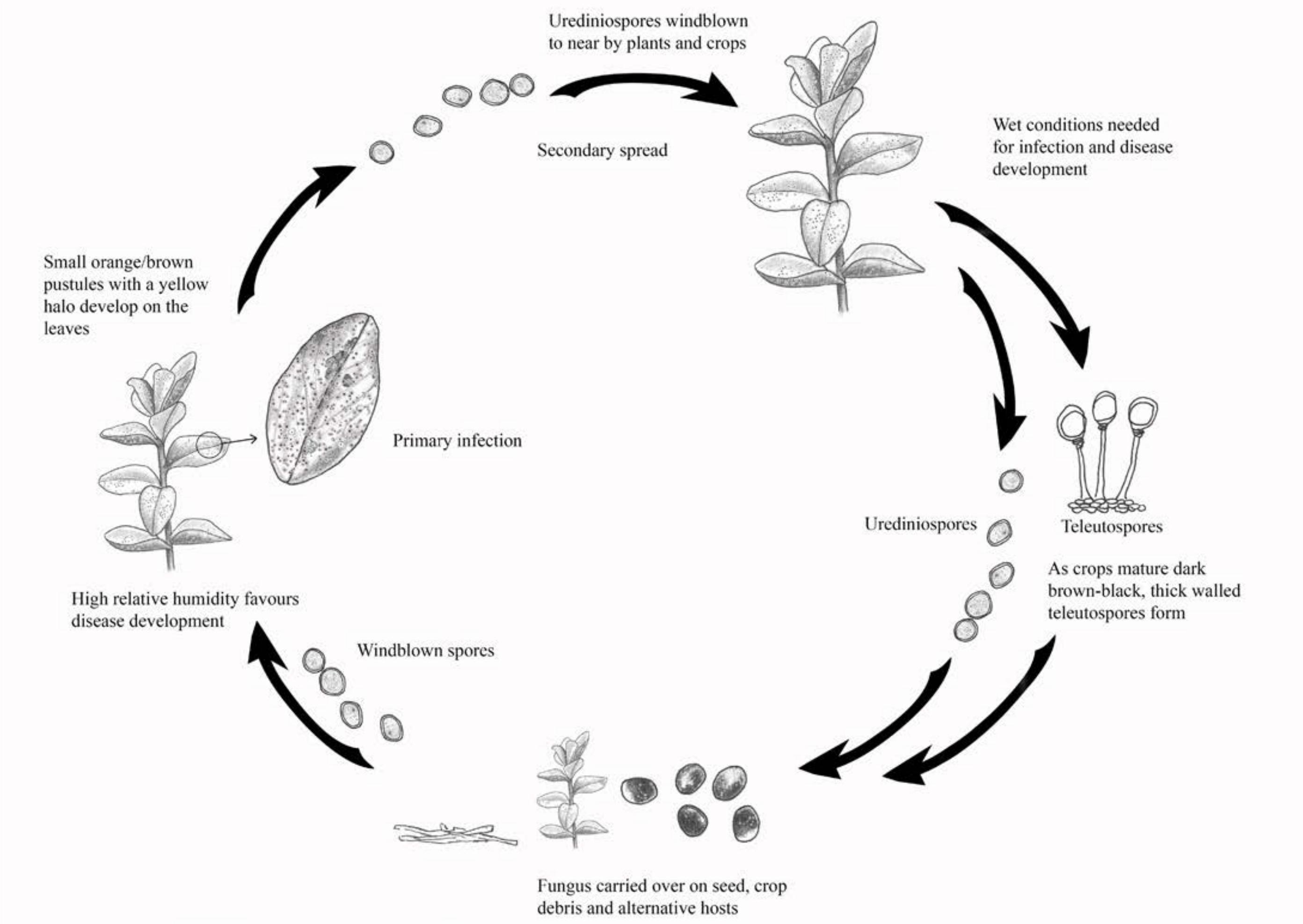


Figure 9.16. Disease cycle of rust on faba beans. Illustration by Kylie Fowler

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/crop-variety-guides

NVT website

nvt.grdc.com.au

Seed Health Testing in Pulse Crops

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals/seed- health-testing-in-pulse-crops

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf

Pulse Australia

www.pulseaus.com.au

Table 9.1. Faba bean disease guide summary

DISEASE	ORGANISMS	SYMPTOMS	OCCURRENCE	HOSTS	CONTROL
Ascochyta blight	*Ascochyta fabae*	Large, light tan to grey spots on leaves. Small black fruiting bodies develop within spots. Centres of lesions may fall out, leaving holes in leaves. Sunken lesions on stem similar in colour to leaf lesions. Brown-black discolouration of grain	Common in all faba bean growing areas in southern Aust. Usually the first disease present in new crops. Most severe in wet seasons	Faba bean, vetch Spores spread by wind and rain Infected seed	Foliar fungicides Resistant varieties Crop rotation Control volunteer plants Clean seed
Chocolate spot	*Botrytis fabae* *Botrytis cinerea*	Passive phase: small chocolate covered spots scattered over leaves Aggressive phase: tissue around spots turn dark grey and black. Leaves die and blacken	Occurs in all areas where beans are grown. Disease usually becomes established in late winter and becomes more severe as day temperatures increase during spring. Can destroy unprotected crops in wet seasons	Faba bean Spores spread by wind and rain	Foliar fungicides Resistant varieties Crop rotation Control volunteer plants
Rust	*Uromyces viciae-fabae*	Numerous small, orange-brown rust pustules, surrounded by a light yellow halo on the leaves of infected plants	Most prevalent in northern Aust. Crops usually affected late in the season	Faba bean	Foliar fungicides Crop rotation Control volunteer plants
Stem nematode	*Ditylenchus dipsaci*	Patches of malformed and stunted plants with curling leaves and watersoak spots. Stem may die back, turning reddish-brown colour	Most severe in wet seasons	Faba bean, pea, oat, wild oat Infected seed straw or soil. Nematode can survive many years in seed, straw or soil	Seed test Crop rotation
Sclerotinia stem rot	*Sclerotinia trifoliorum* var. *fabae*	Infection usually begins close to ground level and slimy wet rot extends into stem and down into the roots. Plants easily pulled from soil and have blackened base covered with cottony, white fungus growth. Usually isolated plants that suddenly wilt and collapse. Sclerotinia on surface and within stem turn from white to black	Rapid development of disease in wet, cool conditions	Wide host range. Foliar form of disease spread by air-borne spores. Fungus survives in the soil for many years	Crop rotation Lower seeding rates, wider row spacings and good weed control
Subterranean clover stunt virus	Virus	Stunting, tip yellowing, small and thick leaves	Prevalent in all bean growing areas. Symptoms appear early on faba bean	Sub clover, faba bean, lupin, lentil, chickpea, lucerne, soybean	Managing aphids and weeds
Bean leaf roll virus	Virus	Interveinal yellowing, leaf rolling, stunting, leathery leaves	Occurs in all bean growing areas	The host range is limited to *Fabaceae*	Managing aphids

FOLIAR DISEASES OF FIELD PEA

Authors: Dr Joshua Fanning (Agriculture Victoria) and Dr Kurt Lindbeck (NSW DPI)

ASCOCHYTA BLIGHT (BLACKSPOT) OF FIELD PEA

Ascochyta blight (blackspot) is the most common and an important foliar disease affecting field pea. It is caused by four pathogens that occur as a complex in the field and cause a single disease where the symptoms caused by each pathogen are undistinguishable in the field. They can all be found on a single diseased plant, but the distribution of pathogens varies between seasons. The pathogens include, *Didymella pinodes* (synonym: *Mycosphaerella pinodes*), *Phoma medicaginis* var. *pinodella*, *Phoma koolunga* and *Didymella pisi*. Laboratory testing is required to determine the causal pathogen. Ascochyta blight is wide spread in Victoria, South Australia and southern New South Wales. The severity of the disease varies greatly from crop to crop and between seasons. In wet seasons when conditions are conducive, yield losses up to 60 per cent have been reported within individual crops, but in a dry season, crop losses are much reduced.

What to Look For

The pathogen infects most parts of pea plants. Both the upper root system below ground level, and the foliage can be infected and show visible symptoms. Early symptoms consist of circular necrotic spots that coalesce into large lesions on leaves (Figure 10.1), stems (Figure 10.2), and pods (Figure 10.3 and 10.4) and a root rot may occur in severe cases. Early infection can cause seedling death (Figure 10.5).

Lesions are purplish-black in colour and cause streaking of the lower stem. Conspicuous spotting of the leaves and pods also occurs. The leaf spots may be either small, irregular, dark-brown and scattered over the leaf, or a few large, circular brown spots. Spots on the pods may combine to form large, sunken, purplish-blackish areas.

Infected seeds may be discoloured and appear purplish-brown. Discolouration is usually more pronounced on those areas of the seed coat next to diseased areas on the surface of the pod. Lightly infected seed may appear healthy.

Figure 10.1. Irregular shaped dark brown to black lesions or flecks on infected leaves and pods (Photo: Joshua Fanning — Agriculture Victoria)

Figure 10.2. Severe infection causing girdling of lower stem. (Photo: Luise Fanning — Agriculture Victoria)

Disease Cycle

The fungi that cause Ascochyta blight may be seed borne, soil borne or survive in pea stubble. The disease usually becomes established when sexual ascospores of the fungus (*D. pinodella*), produced in perithecia on old pea stubble, are carried into the new crop by rain and wind causing early infection. Asexual conidia are produced by other pathogens in pycnidia (fruiting bodies) and can infect pea plants at any stage of plant growth. Pycnidia and perithecia develop on infected plants throughout the growing season and after harvest on pea stubble and infected volunteer plants. Airborne ascospores are the main source of primary infection, whereas the secondary infection is caused by production of conidia (Figure 10.6). Discharge of both types of spores needs rainfall or dew, therefore epidemics are more severe in wetter conditions. Spores produced on infected foliage are transferred onto adjacent healthy plants by wind and rain splash.

The disease can also become established by sowing of infected seed and up to 90 per cent of the crop may be infected. The proportion of diseased seedlings arising from any infected seed lot is influenced by seasonal conditions such as high rainfall and soil factors. In a dry year, the planting of infected seed may not produce a diseased crop, but under wet conditions severe disease is likely.

Management

Ascochyta blight is best controlled by destroying infected pea stubble and self-sown plants. The severity of disease may also be reduced by crop rotation, by the use of disease-free seed, resistant varieties, fungicidal seed dressing and foliar fungicides (in some situations).

Seed selection

Seed should be tested for disease before sowing. Only use seed if less than 5 per cent is infected. Using old or damaged seed can reduce seedling vigour and increase susceptibility to infection.

Figure 10.3. Early or light Black spot infection seen on field pea pods (Photo: Joshua Fanning — Agriculture Victoria)

Paddock Selection

Avoid planting this season's crop near old field pea stubble. Previous pea crop residues can harbour the ascochyta blight pathogens. Aim for a separation of at least 500m from last year's pea paddock.

Crop Rotation

The Ascochyta blight fungi can survive in soil and on old pea stubble; it is only safe to re-crop an area with peas after all pea debris has decomposed. Field pea should not be sown on land planted to pea the previous year nor on land adjacent to pea stubble. Where possible, field pea should not be grown in the same paddock more than once in three years. If disease occurs, the rotation should be extended to one in four or five years. Spores can stay in the soil for several years and a PREDICTA®B test can assist with determining if spores are still within paddocks.

Sowing

Follow the recommended sowing rates and sowing dates for your district. Early sowing increases blackspot risk by increasing the length of time that spores have to affect crops and increases the number of pathogen lifecycles. High sowing rates produces crops with a large canopies and increases the chance of lodging and the humidity of the canopy, thus increasing the risk of developing disease.

Ascochyta Spore Forecasting Model

Blackspot Manager is a forecasting model for Ascochyta blight of field peas. It can be used by agronomists and growers to help identify the best sowing dates that minimize the risk of ascochyta blight without delaying sowing longer than necessary. It can also be used to determine the risk of ascochyta blight at the actual sowing date, so a disease management strategy can be tailored to the risk level. The sowing dates are developed for different rainfall regions after first autumn rains.

Figure 10.4. Severe pod infection showing irregular extended lesions can cause grey-brown discolouration of the seeds (Photo: Luise Fanning — Agriculture Victoria

Blackspot Manager is produced by the Department of Primary Industries and Regional Development (DPIRD) and predictions are made for field pea crops in New South Wales, South Australia, Victoria and Western Australia.

Forecasts are regularly updated on DPIRD Crop Disease Forecasts from April through June each year. The optimum agronomic sowing window for field peas in each of the districts is shown alongside the forecasts.

Destroy Old Crop Residues

Destroying pea stubble by grazing, cultivation and burning will reduce disease risk by minimising the number of spores available to infect new crops. Self-sown peas must also be controlled to prevent carry-over of the disease.

Fungicides

Fungicidal seed dressings registered for use on ascochyta blight of field peas, when applied correctly, will control seed-borne disease and protect young plants from early infection. Where seed is to be inoculated apply the fungicide first and allow to dry. Apply the inoculum immediately prior to sowing. Fungicides and inoculant should never be mixed together. If the potential yield is over 2t/ha, then use P-Pickel T and apply mancozeb (2kg/ha) at the 9 nodes stage and again at early flowering.

Figure 10.5. Severe infection causing seedling death. (Photo: Joshua Fanning — Agriculture Victoria)

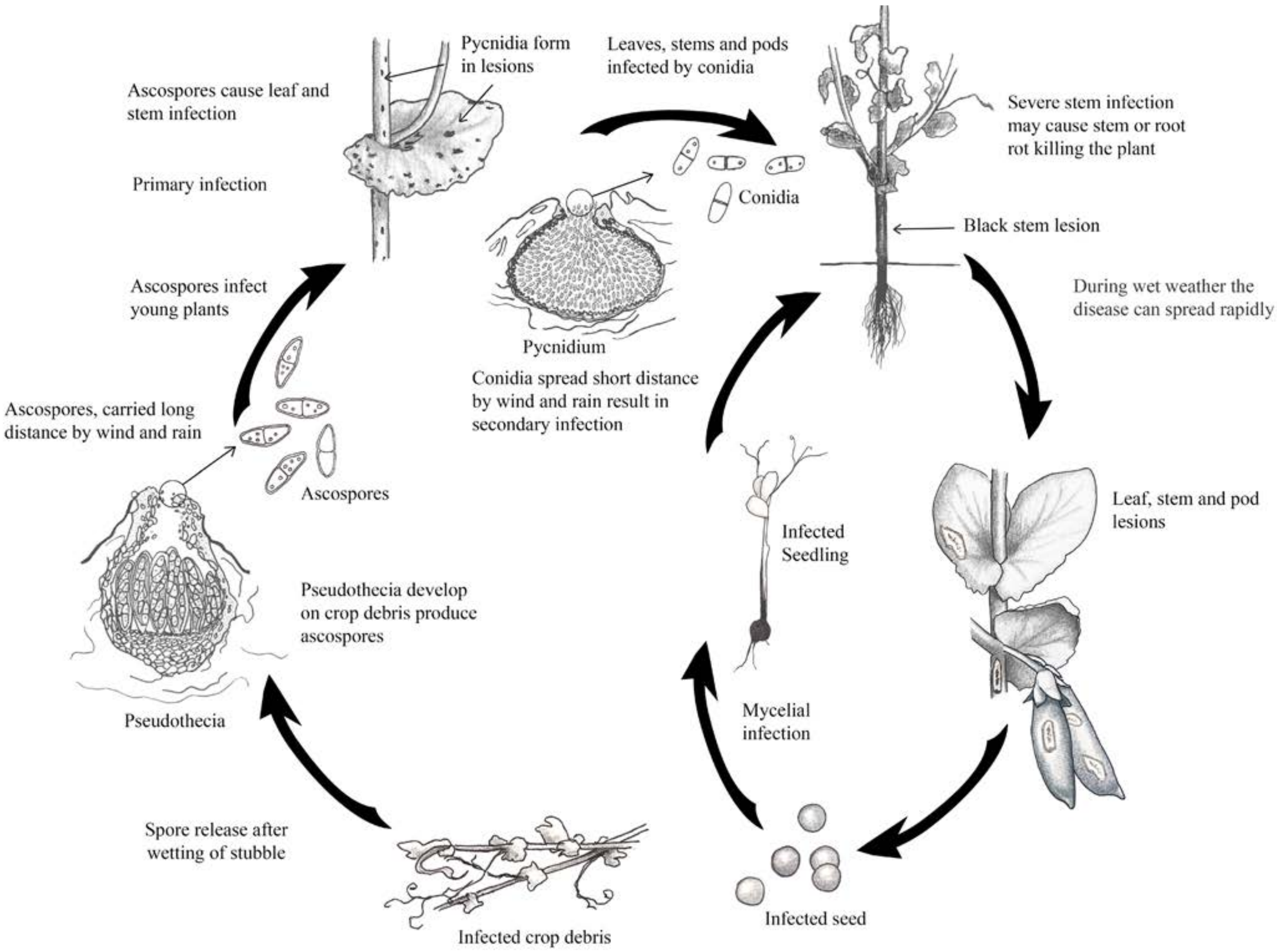


Figure 10.6. Disease cycle of Ascochyta blight of field peas. Illustration by Kylie Fowler

BACTERIAL BLIGHT OF FIELD PEA

This disease, caused by the bacteria *Pseudomonas syringae* pv. *pisi* and *P. syringae* pv. *syringae*, is a serious disease of field pea. Bacterial blight is widespread in field peas in southern New South Wales and Victoria, but its severity varies greatly from crop to crop and between seasons. The disease is seed borne and is more prevalent after frost events or radiating from wheel tracks. Multiple frosts can cause epidemics resulting in significant yield loss.

What to Look For

- Bacterial blight first appears as small, dark green, water-soaked spots on leaves and stipules, often near the leaf base. The spots enlarge and merge but are often limited by the veins.
- The leaf spots turn yellowish and later brown and papery (Figure 10.7).
- Spots on pods are sunken and olive brown.
- Spots can develop on the stem near ground level. These begin as water-soaked areas that later turn olive-green to dark brown. Stem lesions may coalesce, causing the stem to shrivel and die.
- Stem lesions may spread upwards to the stipules and leaflets. In this case, a fan-like lesion is formed on the stipule. Spots can merge causing the stem to shrivel and die (Figure 10.8).
- Pre-emergence and post emergence damping-off may occur and even advanced plants may be killed. Heavily infected seed may be discoloured, but light infection has no visible effect on seed.

The symptoms of Bacterial blight caused by *Pseudomonas syringae* pv. *pisi* or *Pseudomonas syringae* pv. *syringae* are indistinguishable from each other.

Disease cycle

Bacterial blight commonly becomes established within a field by sowing infected seed or from infected pea stubble that is nearby. During wet weather, bacteria spread from infected to healthy plants by rain splash and in wind-borne water droplets (Figure 10.9).

Infection may occur at any stage of plant growth. The pathogens can remain on the surface of plants without causing symptoms. However, following rain, heavy dew, frost or other forms of damage to plant tissues, symptoms can develop.

Damage to field pea provides entry of bacteria into the plant tissue. Early infections may lead to epidemics, but later infection can also cause yield losses. Disease outbreaks tend to be worse in years with frequent frost events and frequent rainfall that enable the disease to become established and spread.

A combination of excessive rainfall and strong winds provides the most favourable conditions for spread of the disease within crops.

Pseudomonas syringae pv. *pisi* is largely restricted to field peas while *P. syringae* pv. *syringae* has a wide host range including clover, common beans, faba beans, lentils, chickpeas and vetch which act as alternate hosts.

Management

Bacterial blight can be avoided by using an integrated approach to management that encompasses planting disease-free seed, crop rotation, variety selection and avoiding early sowing.

Seed Selection

This is the main control measure recommended. The use of clean seed will minimise the possibility of disease, provided the land has not been cropped to peas for several years. Do not use seed from crops identified with bacterial blight during field inspections. A field inspection should occur at mid to late pod fill and/or after every frost event. Bacteria remain viable on seed for at least 2 years.

Cultural Practices

Field pea crops sown into a mulch of cereal stubble are more likely to develop bacterial blight. In winter, the covering of cereal stubble acts to insulate the soil surface and keep temperatures cool, which predisposes field pea plants to frost injury. If sowing field pea into cereal stubble, keep the stubble standing.

Paddock Selection

To obtain a bacterial blight-free crop, pea should not be sown on land sown to pea in the previous year or adjacent to pea stubble. Where possible, pea should not be grown on the same land more than once in three years. If disease occurs the rotation should be extended to once in four years.

Stubble can be a significant source of inoculum. Destroy by burying, baling or burning infected stubble. The survival time of inoculum is significantly reduced by burying pea stubble 10 cm below the soil surface.

Variety Selection

The frequency of bacterial blight can be reduced by avoiding varieties susceptible to *Pseudomonas syringae* pv. *syringae* and sowing those that have better resistance.

Figure 10.7. Leaf lesions caused by Bacterial blight (Photo: Joshua Fanning — Agriculture Victoria)

Sowing

Early sown crops are more vulnerable to bacterial blight infection than late sown crops; never sow earlier than recommended for your district. In areas prone to Bacterial blight avoid early sowing.

Crop Damage

Bacterial blight is often associated with physical crop damage such as hail, frost, strong winds, sand blasting or machinery damage. Physical damage enables bacteria to enter plant tissue. Minimise the use of post emergence herbicide sprays, if possible, as the severity of Bacterial blight can increase if plant tissue is damaged. Avoid paddocks where sulfonylurea residues may be present and the more frost-prone paddocks.

Farm Hygiene

When Bacterial blight is detected, steps should be taken to prevent the spread of disease. This includes restricting access to the affected area. Where possible, harvest infected crops last to avoid contaminating healthy crops and machinery used in an infected crop should be cleaned thoroughly and washed with disinfectant after use. Likewise, machine operators and farm workers should only move from crop to crop after taking precautions against the spread of bacteria. This is best achieved by wearing rubber boots and waterproof trousers that are washed with disinfectant immediately after leaving an infected field. Crops should never be inspected when they are wet as this increases the chance of spreading disease.

Chemical Control

Fungicides and seed treatments are designed to be active against fungal diseases and are ineffective in the control of bacterial diseases. There are copper based compounds, registered for use in field peas against Bacterial blight, but evidence for their effectiveness in Australian field pea crops is limited and inconclusive.

Figure 10.8. Water soaked lesion spreading into the leaf from the base caused by bacterial blight causing the stem to shrivel and die (Photo: Joshua Fanning — Agriculture Victoria)

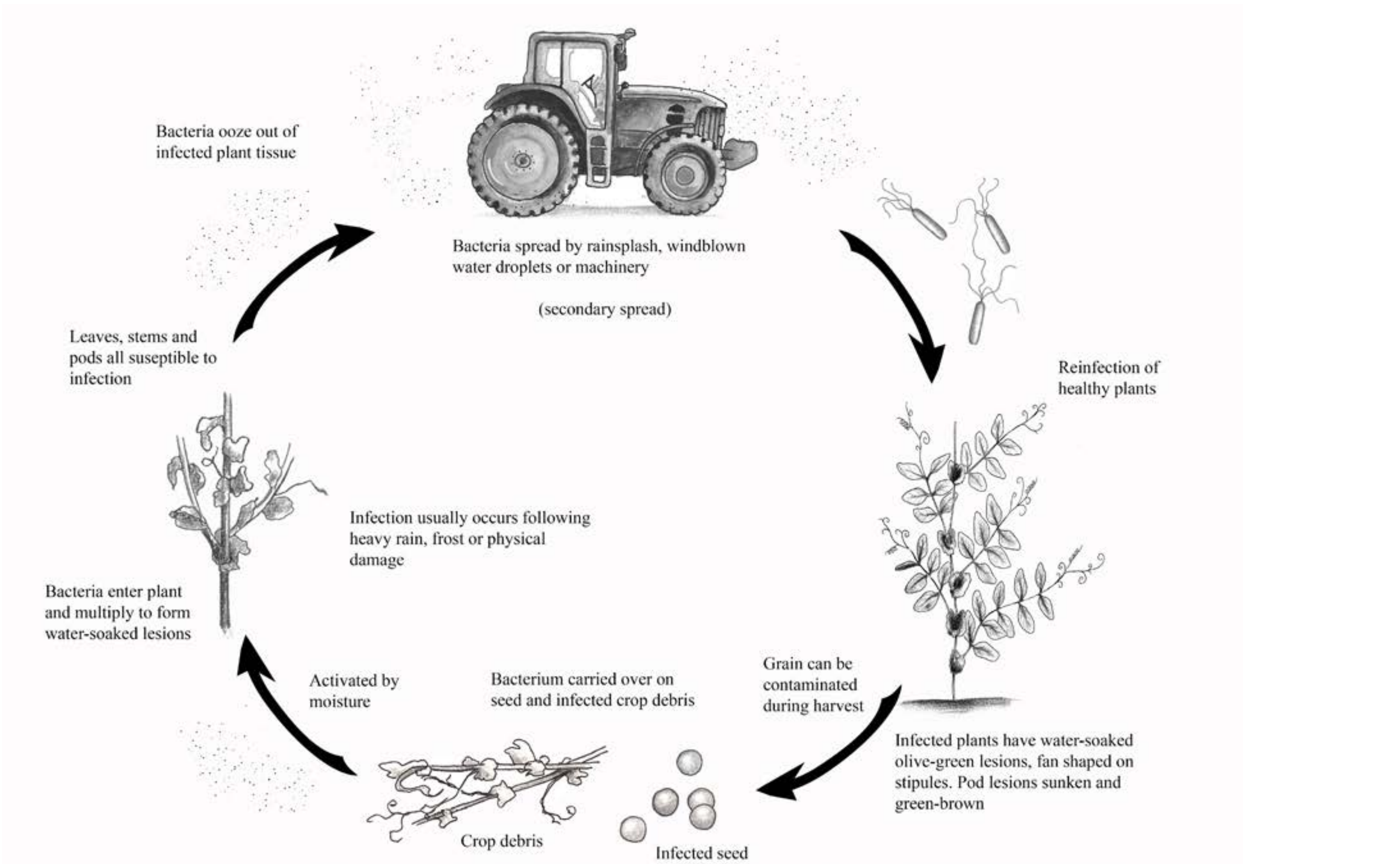


Figure 10.9. Disease cycle of bacterial blight in field peas. Illustration by Kylie Fowler

DOWNY MILDEW OF FIELD PEA

Downy mildew, caused by the pathogen *Peronospora viciae*, is a common disease of field pea in Victoria, South Australia and Tasmania. The disease is favoured by wet, cool seasons.

Night temperatures below 10°C and morning dew promotes the disease. The disease also impairs wax formation on the leaves and makes plants very susceptible to herbicide injury. Systemic infection can lead to the appearance of the disease late in the season if conditions are conducive, but yield losses due to downy mildew arise from the stunting of plants early in the season, or from complete loss of seedlings. Substantial losses can occur in cooler districts.

Figure 10.10. Thick grey fungal growth on lower leaf surface, this is typical of downy mildew (Photo: Joshua Fanning — Agriculture Victoria).

Figure 10.11. Upper leaf surface turns yellow above fungal growth.

What to Look For

The disease is most common soon after emergence, but may affect plants at any growth stage during periods of moist, cool weather. Early infection causes systemic infection in plants that are a sickly yellowish-green and severely stunted and distorted. The undersides of the leaflets, in particular, are covered with a fluffy mouse-grey spore mass (Figure 10.10). Infected plants may turn chlorotic while producing an abundant source of spores for secondary infections.

Secondary infection is localised in upper leaves, stems, tendrils and pods and results in the appearance of isolated greenish-yellow to brown blotches on the upper leaf surface (Figure 10.11). On the lower surface directly below the lesions are masses of mouse grey fruiting bodies that produce spores under wet and cold conditions. Infected pods are deformed and are covered with yellow to brownish areas and superficial blistering. The fungus usually affects the lowest leaves and pods (Figure 10.12).

The fungus that causes downy mildew survives 10-15 years in the soil and also on pea stubble. Infection from these sources can lead to systemic and local leaf infections in volunteer pea seedlings. These seedlings act as a source of infection from which the disease spreads by wind to adjacent plants and crops. The disease can develop quickly when conditions are cold (5-15°C) and high humidity (over 90 per cent RH) for 4-5 days, often when seedlings are in the early vegetative stage. Rain is the major means of spore dispersal and infection.

Heavy dew will promote sporulation. Dry, warm weather is unfavourable for the disease. Systemic infection of plants can lead to the disease developing late in the season if conditions are favourable (Figure 10.13).

Generally plants will grow away from the disease as temperatures increase in late winter/early spring without significant yield loss.

Management

Variety Selection

Growing a resistant field pea variety is the most effective means of controlling downy mildew in districts prone to this disease.

There are two strains of the downy mildew fungus, the Parafield and Kaspa strains. The Parafield strain is considered a non-virulent strain that infects all conventional type tall field peas, whereas the new Kaspa strain is more virulent and can infect both conventional type, older field pea varieties as well as newer semi-leafless varieties. Consult the latest disease guide for up to date ratings.

Crop Rotation

Extended crop rotations and destruction of infected pea stubble will minimise the risk of serious disease. Extended crop rotations allow spore numbers in the soil to decline before sowing again to field peas. A break of at least 3 years between field pea crops is recommended. Avoid sowing pea crops adjacent to last season's stubble.

Chemical Control

Seed dressing with metalaxyl or oxadixyl (Group 4 systemic phenylamide fungicides) can be effective but have shown deleterious effect upon rhizobium inoculant. Seed treatments reduce the number of seedlings with primary infection, thereby reducing the amount of air-borne spores that cause secondary infection in the surrounding crop. Seed treatments are recommended for districts where downy mildew occurs in most years. Not all fungicide seed dressings have activity against downy mildew.

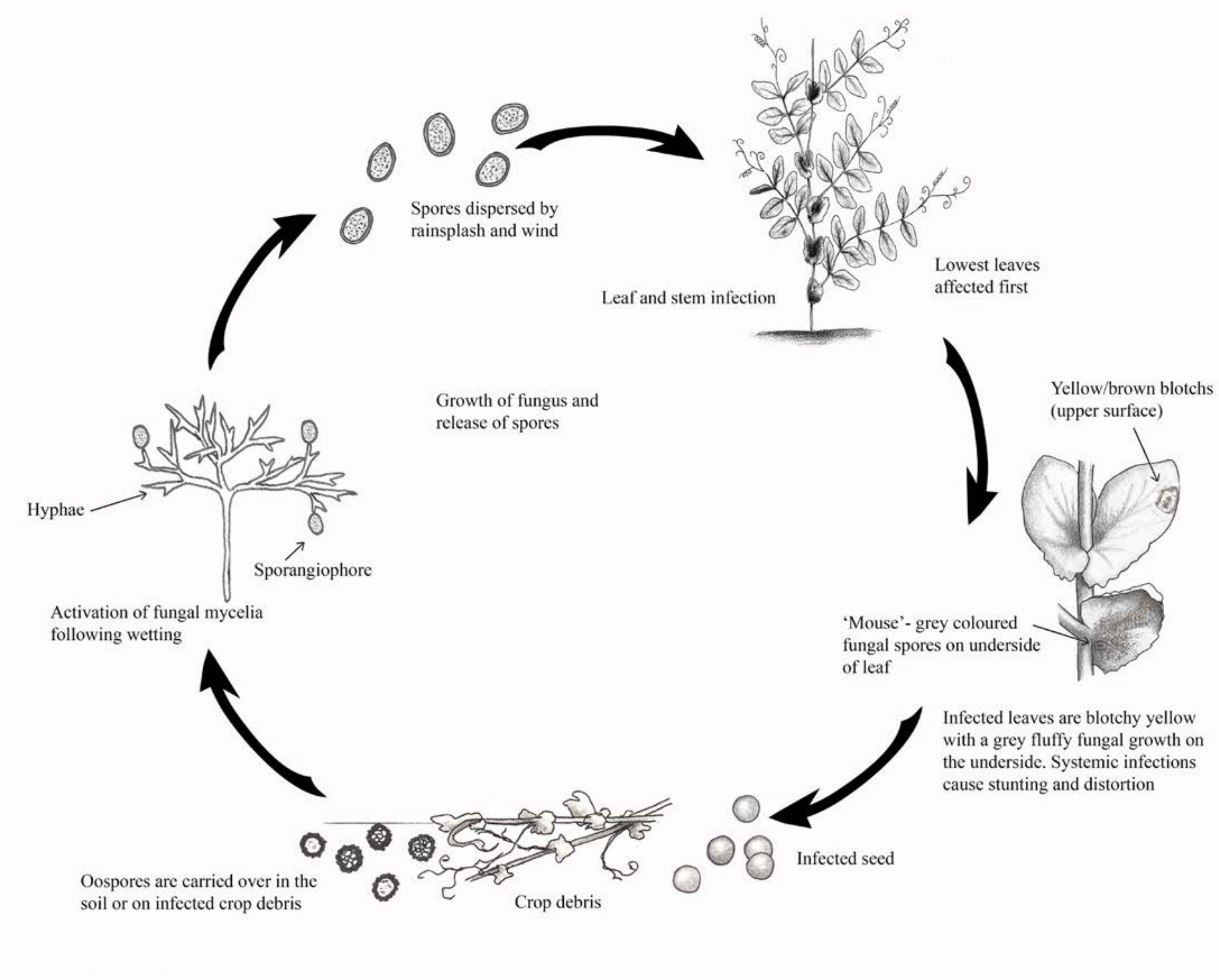


Figure 10.12. Disease cycle of downy mildew on field peas. Illustration by Kylie Fowler.

POWDERY MILDEW OF FIELD PEA

Powdery mildew, caused by the pathogen *Erysiphe pisi*, can be a serious disease of peas in South Australia and Victoria. Severe infections can significantly reduce yield in susceptible varieties. Powdery mildew is most prevalent late in the season when warm days and cool nights result in dew formation.

***Note**: Downy mildew is caused by* Peronospora viciae *and is not the same fungus that causes powdery mildew.*

What to Look For

Infected plants are covered with a white powdery film. Severely infected foliage turns blue-white in colour; tissue below these infected areas may turn purple (Figures 10.13 and 10.14). Symptoms first appear on the upper surfaces of the oldest leaves. Leaves, stems and pods may all become infected resulting in withering of the whole plant. Severe pod infection can cause a grey-brown discolouration of the seeds. These seeds have an objectionable flavour that lowers the quality of the grain.

Disease Cycle

The fungus over-winters on infected pea stubble and produces spores which are blown by wind into new crops (Figure 10.15). Under favourable conditions the disease may completely colonise a plant in 5-6 days and once a few plants become infected it rapidly spreads to adjacent areas.

Warm (15-25°C), humid (over 70 per cent) conditions for 4-5 days late in the growing season during flowering and pod filling are favourable for disease development. Rainfall is not favourable for the disease, as it will wash spores off plants. Dewy nights are sufficient for disease development.

Figure 10.13. Typical white powdery growth on an infected plant.

Figure 10.14. Powdery mildew infects all of the plant including pods.

Management

Variety Selection

Growing a resistant variety is the most effective means of controlling powdery mildew. Resistant varieties are immune to this disease and do not develop disease throughout the growing season.

Crop Rotation

Leave a four-year break between growing field pea crops in the same paddock. Control volunteer field peas which can harbour disease. Avoid sowing field pea crops adjacent to last season's stubble. Incorporate or burn infected pea stubble soon after harvest where practicable.

Fungicides

Powdery mildew can be effectively controlled by fungicide sprays. Monitor crops from flowering onwards for signs of powdery mildew. If the disease is present the application of a foliar fungicide may be warranted. Fungicides need to be applied very early in disease development to be most effective. Fungicides for powdery mildew have limited systemic activity and will not protect the new growth following spraying. Good plant coverage with the fungicides is essential. Depending on disease pressure, foliage is protected for about 14 days.

***Note**: Fungicides used to control downy mildew have no activity against powdery mildew.*

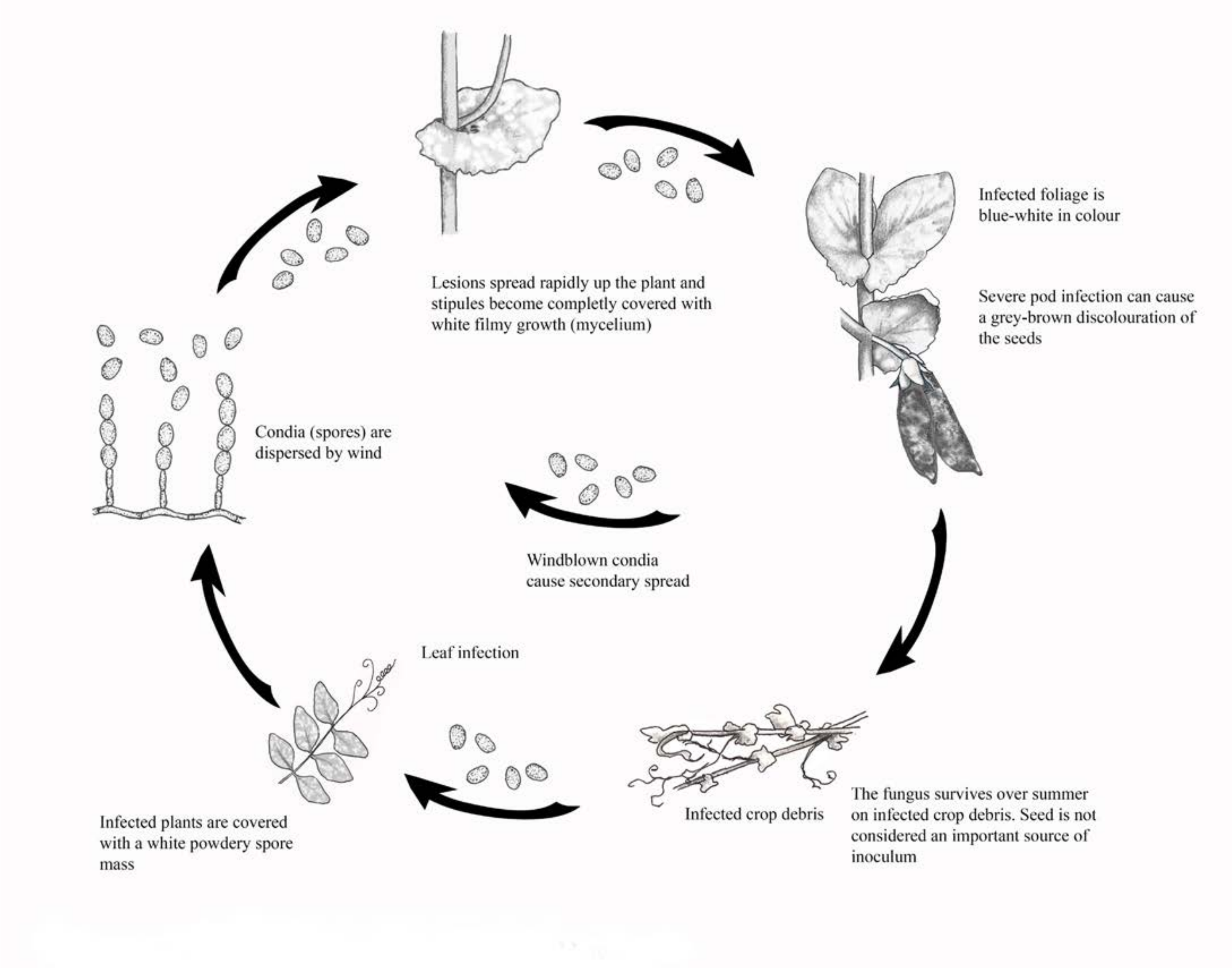


Figure 10.15. Disease cycle of powdery mildew of field peas. Illustration by Kylie Fowler

SEPTORIA BLIGHT OF FIELD PEA

Septoria blight is caused by the fungus *Septoria pisi*. Septoria blight is a minor disease and appears to have little effect on the yield of most pea varieties. The disease has been particularly noted in New South Wales but occurs sporadically in Victoria and South Australia. The disease is often seen on old foliage, pods and stems late in the growing season.

What to Look For

The disease is found mainly on the lower, senescing parts of the plant and the pods. The disease is characterised by yellow blotches on plant tissue, which become necrotic and covered in numerous brown spots. Lesions vary in size, are roughly circular and have no distinct margin. First they appear yellow later becoming straw-coloured. Several such blotches may join to cover the entire leaf. As the blotches dry out many pinpoint-sized black pycnidia (fungus fruiting bodies) may be seen scattered widely on infected plant parts, including pods (Figure 10.16). Diseased tissues may dry off prematurely.

Disease Cycle

The fungus over-winters on infected pea stubble and seed. Spores of the fungus are carried by wind from infected stubble into the new crop (Figure 10.17). Infection is found on the lower foliage where the humidity is high following rain or heavy dews. Disease development favours prolonged high humidity (at least 24 hours) and moderately warm temperatures of 21-27°C. Rain splash assists in spreading the disease within a field. Whilst seed-borne transmission can occur it is less important.

Management

Septoria blight can be managed through crop rotation. The septoria blotch fungus survives in soil and on old pea stubble. It is only safe to re-crop an area with peas after all pea debris has decomposed. Destroying pea stubble by grazing, burning and cultivation will help in reducing the pea debris more quickly.

Figure 10.16. Typical leaf and pod lesions caused by Septoria infection. These blotches are brown and angular, containing very small brown to black spots (Photo: Joshua Fanning — Agriculture Victoria).

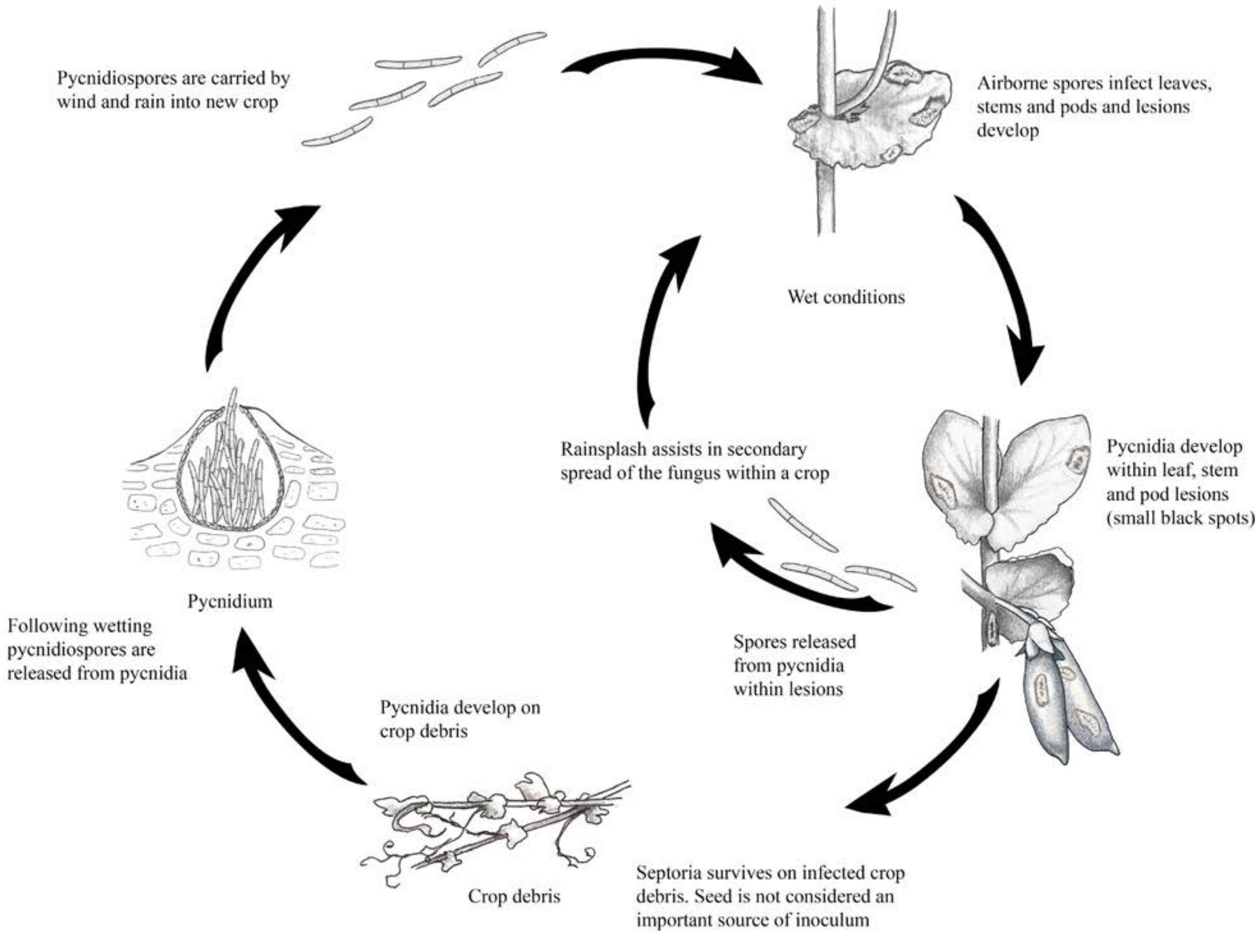


Figure 10.17. Disease cycle of Septoria of field peas. Illustration by Kylie Fowler

Table 10.1. Field pea disease guide summary

DISEASE	ORGANISMS	SYMPTOMS	OCCURRENCE	HOSTS	CONTROL
Ascochyta blight	*Didymella pinodes* (synonym: *Mycosphaerella pinodes*), *Phoma medicaginis* var. *pinodella, Phoma koolunga* and *Didymella pisi.*	Most obvious on stems and leaves. Purplish-black discolouration of lower stem. Dark brown spotting of pods and leaves. Blackening of tap root	Common in all pea growing regions; most crops are affected to some extent. Favoured by wet conditions. Most damage in early sown crops	Peas and most legumes	Crop rotation. Later sowing. Seed dressings. Disease free seed
Bacterial blight	*Pseudomonas syringae* pv. *pisi* and *P.syringae* pv. *syringage*	Water-soaked spots on leaflets and stipules. Yellowish brown fan-shaped lesion on stipules	Sporadic in wetter regions. Most severe in early sown crops already damaged by frost or heavy rain	Peas for *pv. pisi* and alternate hosts for pv. *syringae*	Crop rotation. Disease free seed. Resistant varieties
Downy mildew	*Peronospora viciae*	Brown blotches on upper leaf surface. Underside of leaves covered by masses of fluffy 'mouse-grey' spores	Sporadic in all regions. Damage most severe in wetter districts	Peas	Resistant varieties. Seed fungicide treatment
Powdery mildew	*Erysiphe pisi*	Leaves covered by a film of powdery white spores. Infected plants have a blue-white colour	Can occur in most regions towards the end of the season. Most common in late-sown crops	Peas	Resistant varieties. Avoid late sowing. Apply Foliar fungicide at flowering as an economic option for disease prone areas
Septoria leaf blotch	*Septoria pisi*	Straw coloured blotches on leaves, stems and tendrils. Pin-head size black spots within lesions	Present in most pea growing regions. Damage most severe on short, semi-leafless varieties	Peas	Destroy crop residue. Most varieties are moderately susceptible. Crop rotation
Pea seed borne mosaic virus	Virus	Downward curling of leaves, mosaic, stunting	Present in all pea growing regions	The host range is limited to *Fabaceae*	This virus is highly seed-borne in peas. Virus-free seed is recommended

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/crop-variety-guides

NVT website

nvt.grdc.com.au

Seed Health Testing in Pulse Crops

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals/seed- health-testing-in-pulse-crops

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf

Pulse Australia

www.pulseaus.com.au

FOLIAR DISEASES OF LENTIL

Authors: Dr Joshua Fanning (Agriculture Victoria) and Dr Kurt Lindbeck (NSW DPI)

ASCOCHYTA BLIGHT OF LENTIL

Ascochyta blight of lentil and is an important disease in most lentil producing countries and is caused by the pathogen *Ascochyta lentis*. The disease can reduce crop yields and affect seed quality and hence marketability. Seed with discolouration caused by Ascochyta infection is often heavily discounted in price and may be rejected by some buyers. Ascochyta blight develops in cool, wet conditions and is likely to be a problem in years with a wet winter or high rainfall areas. Heavy rainfall during podding can result in pod infection and is likely to develop when the disease is already present in the crop

Figures 11.1. and 11.2. Characteristic leaf lesions caused by Ascochyta blight of lentil (Photo: Joshua Fanning – Agriculture Victoria)

Figure 11.3. Pod lesion caused by Ascochyta infection

Figure 11.4. Lentil seed infected with Ascochyta blight. Note dark brown margin and fruiting bodies present in (left), healthy seed (right) the centre of the lesions

What to Look For

All above ground parts of lentil plants can be affected by Ascochyta blight. Symptoms can appear on plants at any growth stage, with infection looking more severe when plants are smaller. The disease appears as spot-like lesions which are initially light grey and then develop a tan to dark brown margin (Figures 11.1 and 11.2).

The centre of lesions become speckled with pycnidia (tiny, dark fruiting bodies) (Figures 11.1 and 11.2). The presence of pycnidia is the best way of identifying ascochyta blight lesions from those caused by other diseases such as botrytis grey mould or stemphylium blight. Heavy infections of Ascochyta blight will cause premature leaflet drop and stem dieback at the growing tips giving plants a blighted appearance.

Crops which have leaf or stem lesions are at greater risk of developing pod infection. Pod infection can lead to seed infection and discolouration of the grain. Infected seed generally has brown patches on the seed surface, but may show no symptoms at all. Compared to healthy seed, heavily infected seed is purplish-brown, shrivelled and reduced in size (Figure 11.2).

Disease Cycle

The causal of Ascochyta blight, *Ascochyta lentis* can carry over in infected seed or survive on infected stubble from previous diseased crops (Figure 11.5). It is important to keep in mind even with sowing clean seed and a good paddock rotation, *A. lentis* can infect new crops when spores from infected stubble are carried by the wind from old lentil paddocks. Infection can occur at any stage of plant growth; however, moisture is essential. Cool, wet weather promotes sporulation, spore dispersal and infection. Secondary spread within crops occurs when spores produced on diseased plants are a carried by wind and rain-splash onto neighbouring plants. Heavy rainfall late in the season provides ideal conditions for pod infection and subsequent seed discolouration.

Management

Seed Selection

Using old or damaged seed can reduce seedling vigour and increase susceptibility to infection. Only sow seed with less than 5 per cent Ascochyta infection and preferably use seed with no infection.

Variety Selection

Sow varieties with the greatest resistance. There are a range of varieties available that are MR or R to Ascochyta infection with attributes to suit most lentil growing areas in Victoria. It is important to check the latest resistance ratings as they may change as resistance breaks down. Refer to the latest Victorian Pulse Disease Guide or the NVT Website for up to date ratings.

Paddock Selection

Infected crop residues can harbour *Ascochyta lentis*. Therefore, avoid planting this season's crop near old lentil stubble. A program of stubble reduction may also be undertaken by grazing or burying to reduce the carry-over of infected stubble into the following season. Allow a break of at least 3 years between lentil crops.

Seed Treatment

Use a registered seed treatment for the control of seed-borne diseases in lentil. Seed treatments can have a deleterious effect on rhizobia. Therefore, seed should be treated with fungicide and then inoculated with rhizobia in two separate operations.

Rhizobia should be applied to seed immediately before sowing, especially on acid soils.

Sowing

Early sowing encourages early infection and increased levels of the disease. Follow the recommended sowing dates for your district.

Foliar Fungicides

In areas of high risk, it may be necessary to apply foliar fungicides to protect crops especially if a susceptible variety is grown. Use a registered product and remember many fungicides are protectants and are most effective if applied before disease development.

Fungicides should be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.

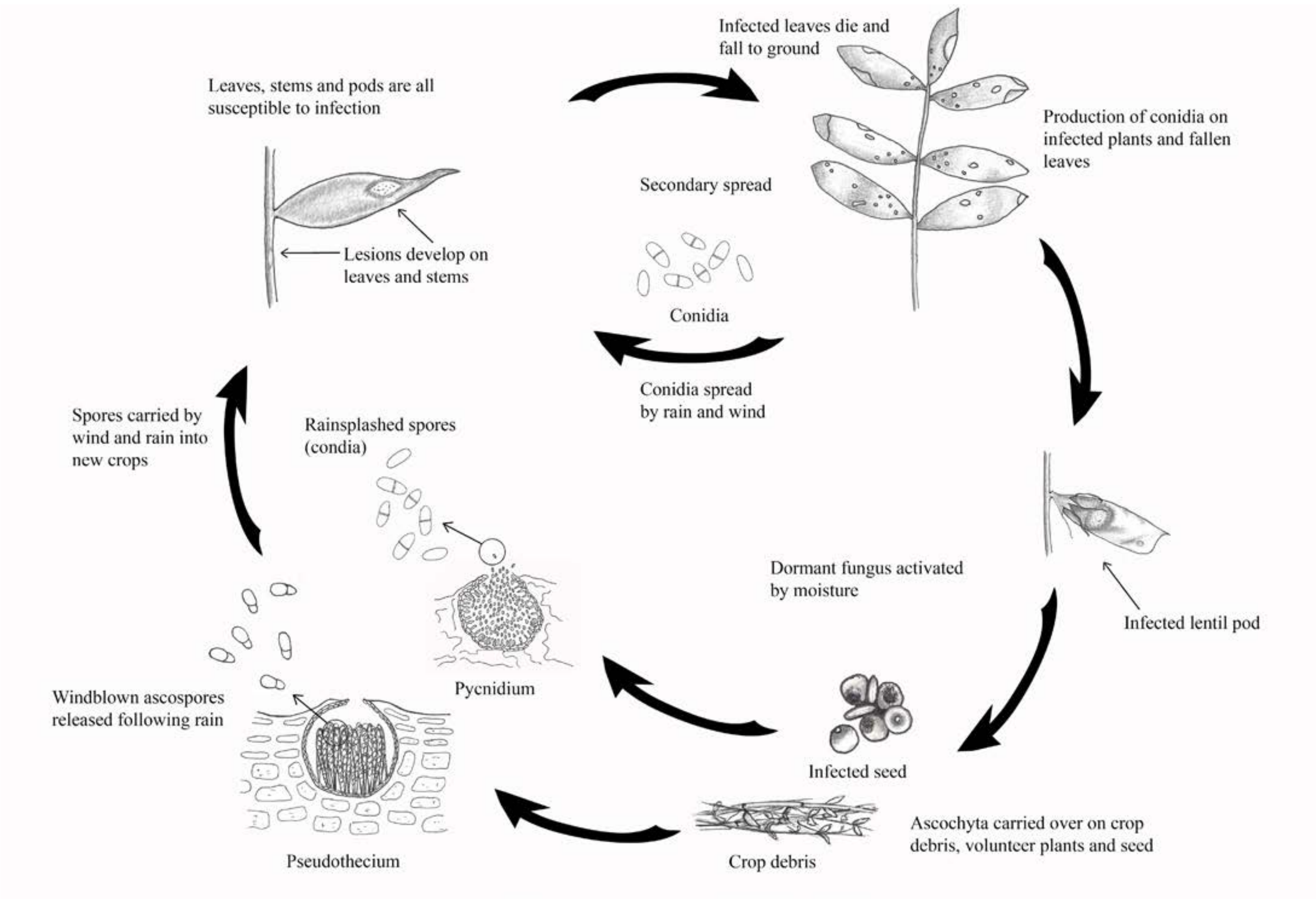


Figure 11.5. Disease cycle of Ascochyta blight of lentil. Illustration by Kylie Fowler

BOTRYTIS GREY MOULD OF LENTIL

Botrytis grey mould of lentil is a foliar disease caused by the fungal pathogens *Botrytis cinerea* and *Botrytis fabae*. Botrytis grey mould (BGM) has been reported in many lentil growing countries of Asia and throughout North America but appears to be more severe in Australia.

What to Look For

The disease can infect all above ground parts of the lentil plant, including leaves, stems and pods. The first symptoms are discrete greyish-brown lesions on the lower leaves of the plant (Figure 11.6). Differentiating it from Ascochyta blight is easy, as BGM has no black fruiting bodies (pycnidia) within the lesions.

Infected leaves can become covered with a fuzzy layer of grey mould toward the base of the plant (Figure 11.7). Stem lesions will appear light brown or bleached and can be covered in grey, mouldy growth. The mouldy growth consists of spore masses that can quickly spread to infect surrounding plants. Clouds of spores can rise from infected plants if they are disturbed. Dark black fungal survival bodies, known as sclerotia, can develop on stems and it is these structures that survive over summer on lentil stubble. Severely infected leaves, flowers and pods wilt and fall to the ground. Plants ripen prematurely due to infection of the lower stem. If conditions remain wet throughout spring, stems can become girdled and patches of brown dying plants appear in the crop (Figure 11.8).

Infected pods will fail to fill properly and will produce shrivelled seed or no seed at all (Figure 11.9). Infected seed is discoloured.

Figure 11.6. Greyish-brown spots on leaflets of a botrytis grey mould infected lentil plant (Photo: Joshua Fanning – Agriculture Victoria)

Figure 11.7. Characteristic early stem/leaf infection caused by botrytis. Note grey, fuzzy spore mass and black sclerotia (Photo: Joshua Fanning – Agriculture Victoria)

Figure 11.8. Patches of dying lentil plants at a trial site in South Australia in 2005. (Photo: Kurt Lindbeck – NSW DPI)

Figure 11.9. Lentil pod with symptoms of BGM. Note the typical dark grey, fuzzy growth of the fungus (Photo: Kurt Lindbeck – NSW DPI)

Disease Cycle

The pathogens (*Botrytis cinerea* and *B. fabae*) can survive on stubble residue (lentil, vetch, chickpea or faba bean), in the soil as sclerotia or can also be carried on infected seed. The disease inoculum readily survives on alternate hosts such as vetch (*Botrytis cinerea* and *B. fabae*), faba bean, (*Botrytis fabae*) and chickpea (*Botrytis cinerea*), which are also grown in close rotation with lentil. When seed infected by these fungi are sown, seedling blight will occur soon after crop emergence, reducing plant densities. Masses of spores are produced on infected plants which can then spread onto surrounding plants by wind and rain-splash to begin new infections (Figure 11.10).

Symptoms of grey mould appear more commonly in early spring following canopy closure, when the canopy does not dry out as readily. Dense crop canopies combined with warm, wet conditions in late winter and early spring favour development and spread of the disease. Often symptoms of BGM first appear in double sown areas of the crop.

Moisture within the crop canopy is essential for infection. Lentil crops sown early and/or at high seeding rates appear to be the worst affected by BGM. The disease usually starts off affecting lower leaves and the base of the stem. Prolonged wet conditions during the growing season can cause the disease to progress higher up the plant, subsequently affecting pods.

Management

Seed Selection

Only use seed with less than 5 per cent botrytis infection; ideally use seed with no infection. Using old or damaged seed can reduce seedling vigour and increase susceptibility to infection. See Seed Health Testing in Pulse Crops (further information) for more information.

Variety Selection

Use varieties with greater resistance to botrytis grey mould. It is important to check the latest resistance ratings as they may change as resistance breaks down. Refer to the latest Victorian Pulse Disease Guide or the NVT Website for up to date ratings.

Paddock Selection

Avoid planting this season's crop near old lentil, faba bean, chickpea, vetch or lathyrus stubbles. These crop residues can harbour *Botrytis fabae* or *Botrytis cinerea*. A program of stubble reduction may also be undertaken by grazing or burying to reduce the carryover of infected stubble into the following season. Allow a break of at least 3 years between stubbles to reduce the chance of inoculum carryover.

Seed Treatment

Use a registered seed treatment for the control of seed-borne diseases of lentil. Seed treatments can have a deleterious effect on rhizobia. Therefore, seed should be treated with fungicide and then inoculated with rhizobia in two separate operations. Rhizobia should be applied to seed immediately before sowing, especially on acid soils.

Sowing

Sowing later and reducing seeding rates will lower disease risk. Early sowing and high sowing rates can cause higher biomass and increase the chance of lodging and therefore increases the risk of grey mould. Follow the recommended sowing rates and sowing dates for your district.

Foliar Fungicides

In areas of high risk it may be necessary to apply foliar fungicides to protect the crop, especially if a susceptible variety is being grown. Fungicides should be applied before canopy closure for best results. If conducive (warm and wet) conditions continue, follow up sprays may be necessary, particularly in susceptible varieties.

There are a range of fungicides available to control BGM and selection of the most appropriate fungicide could depend on the level of disease pressure present and the variety resistance rating. It is worth noting that some fungicides are protectants and are most effective if applied before disease development.

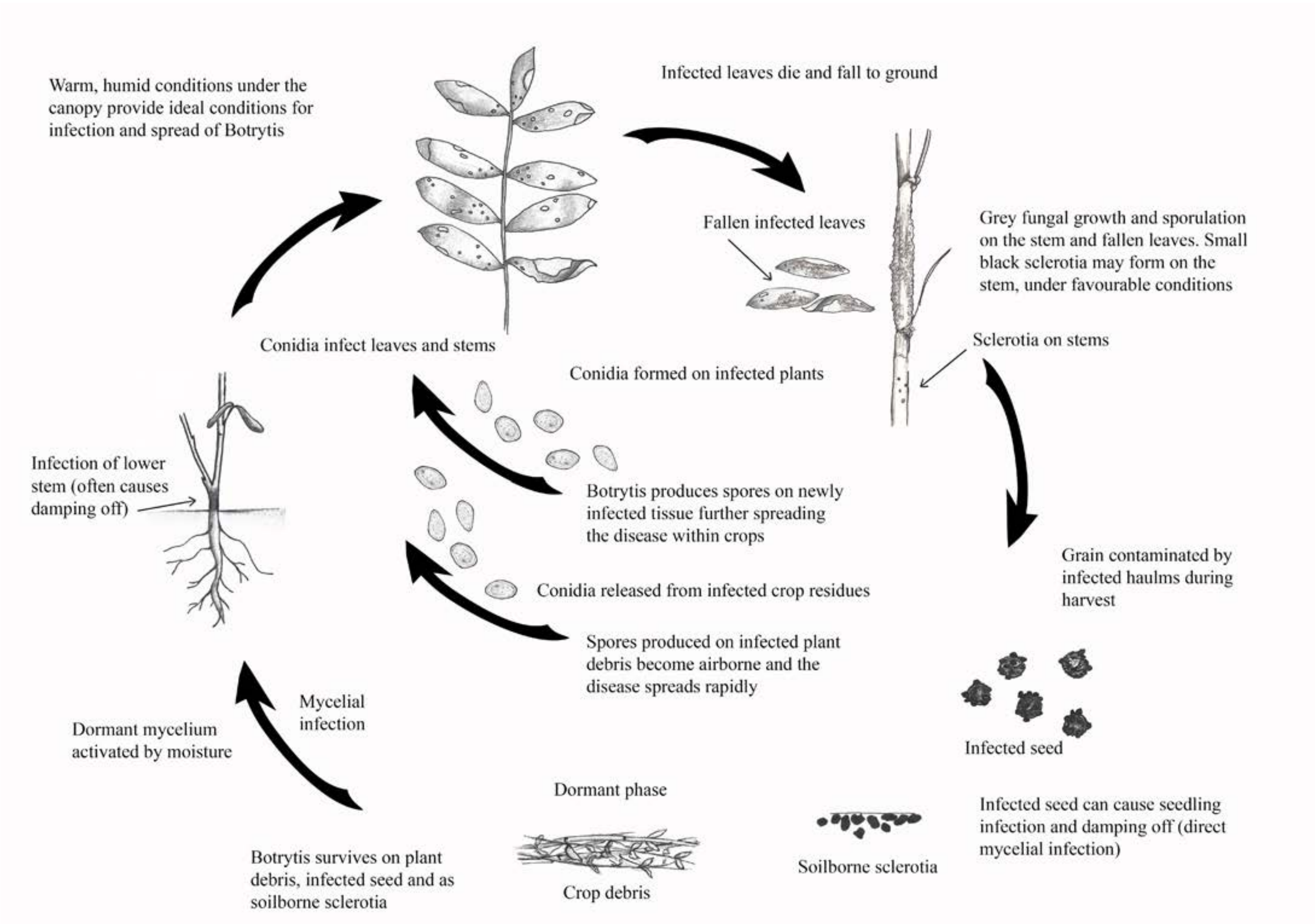


Figure 11.10. Disease cycle of Botrytis grey mould of lentil. Illustration by Kylie Fowler

EXOTIC TO AUSTRALIA

LENTIL ANTHRACNOSE

***Note**: Lentil anthracnose is an exotic disease and has not been detected in Australia to date.*

Lentil anthracnose is a serious disease of lentil worldwide. It has been identified in Bangladesh, Bulgaria, Canada, Ethiopia, Morocco, Pakistan, Syria and the USA. This disease is most serious in Canada where it causes yield losses of up to 60 per cent. Lentil anthracnose is caused by the fungal pathogen *Colletotrichum truncatum*. Screening of Australian breeding lines in Canada has shown that current lentil varieties in Australia are all highly susceptible to this disease.

What to Look For

In most lentil crops, the first symptoms of anthracnose appear before flowering when the plants have 8 to 12 nodes on the main stem. This is also the time when the first tendrils form and approximately a week before flowers start to open. If there is a large amount of inoculum in the field the first symptoms may appear earlier. The initial symptoms of lentil anthracnose are greenish water-soaked lesions on the lower stems and leaves that become necrotic with time. Tan coloured lesions of variable size develop on the lower leaflets and the most severely affected leaflets die prematurely and drop to the ground (Figure 11.11). Creamy white lesions are also sometimes evident on the upper foliage.

Small, pinhead sized fungal structures (microsclerotia) form on the older infected plant tissue. They may be seen with the unaided eye in the centre of stem lesions or more easily with a hand lens (10-15x magnification) (Figure 11.12). Each microsclerotia consists of a few hundred cells with thick, black cell walls that protects the fungus from colonisation by other microorganisms (Figure 11.12). Microsclerotia enable the fungus to survive between lentil crops either on the plant debris or free in the soil. They remain viable longer when buried in the soil by tillage than left exposed to weather extremes on the soil surface. These fungal structures survive on dead lentil debris or in the soil during periods when a host is not available.

During flowering, lesions on stems develop soon after the appearance of leaf lesions primarily at the base of the plant. Stem lesions may be small, brownish with a black border, or larger, stretching along the stem (Figures 11.13 and 11.14). As the season progresses, more and more golden-brown lesions develop at the stem base, as well as on the upper part of the stems and many stems are girdled. Finally, there is a marked blackening of old infected tissues due to the production of stromatic mycelium (microsclerotia) under acervuli.

Anthracnose causes defoliation and stem girdling which inhibits utilisation of water and nutrients and causes the lentil plants to wilt. The fungus girdles the stem resulting in wilting of the entire plant, and large areas of brown and dying plants in the field.

Disease Cycle

The disease can survive on infected lentil seed, plant debris and in the soil. Seed-borne inoculum is considered to be of minor importance in Canada. Infected seed will give rise to infected seedlings, which can establish the disease in new crops and in new areas. Infected stubble residues and dust play a more important role in the spread and survival of this pathogen. Windblown residues and dust spread the disease

Figure 11.11. Distinct stem lesions caused by Colletotrichum truncatum *infection. These are pale brown with a black border and irregular in shape*

Figure 11.12. Close up of a lentil Anthracnose lesion showing microsclerotial survival structures

into nearby paddocks and new lentil crops. Microsclerotial fruiting bodies, formed on infected plant tissue, allow the pathogen to survive in the soil for up to 4 years in the absence of lentil hosts.

Management

Current management strategies in Canada involve the use of foliar fungicides to protect plants from infection. There are no resistant varieties currently available, although, they are being developed.

Figure 11.13. Field shots of Anthracnose stem lesions (they appear very similar to Ascochyta lesions)

Figure 11.14. Field shots of Anthracnose stem lesions (they appear very similar to Ascochyta lesions)

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/crop-variety-guides

NVT website

nvt.grdc.com.au

Seed Health Testing in Pulse Crops

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals/seed- health-testing-in-pulse-crops

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf

www.pulseaus.com.au/growing-pulses/crop-protection-products

Pulse Australia

www.pulseaus.com.au

Table 11.2 Lentil disease guide summary

DISEASE	ORGANISMS	SYMPTOMS	OCCURRENCE	HOSTS	CONTROL
Ascochyta blight	*Ascochyta lentis*	On leaves, small round whitish lesions with brown margins. Lesions often containing small black fruiting bodies of the fungus. Lesions can also form on stems causing premature death. Pod infection can ultimately result in black discolourations on seed	Common in all lentil growing regions in southern Australia. All varieties except Northfield are at risk of seed infection by ascochyta blight. Damage is most likely in wet seasons	Lentils – seed, stubble and self-sown plants	Seed dressings. Resistant varieties. Foliar fungicides. Crop rotation. Avoid early sowing
Botrytis grey mould	*Botrytis* spp.	Leaves: White round lesions-spots without black fruiting bodies as in ascochyta blight. Stems: Light brown sections form on stems that are covered with fluffy grey mould. Botrytis grey mould can cause branches to die and cause discoloured and shrivelled seed. In severe cases large brown patches can form in the crop	Most likely to occur in dense, lodged crops when there is frequent rain late in spring	Most legumes	Seed dressings. Low plant density. Avoid early sowing. Foliar fungicides. Crop rotation. Resistant varieties
Alfalfa mosaic virus	Virus	Tip necrosis	Prevalent in lentil production regions	Wide host range including most pulses, some horticultural plants and weeds	Virus free seed, management of weeds, resistant varieties
Cucumber mosaic virus	Virus	Yellowing, stunting	Common in all lentil growing areas	Very wide host range, including most pulses, pastures, horticultural crops and weeds	Virus free seed, management of weeds, resistant varieties
Beet western yellows virus	Virus	Yellowing, stunting	Present in all lentil production areas	Very wide host range. Most pulses and brassicas and many weed species	Managing weeds and aphids, resistant varieties

FOLIAR DISEASES OF LUPIN

Authors: Dr Kurt Lindbeck (NSW DPI) and Dr Joshua Fanning (Agriculture Victoria)

BROWN LEAF SPOT/PLEIOCHAETA ROOT ROT OF LUPINS

The fungus *Pleiochaeta setosa* causes both brown leaf spot and Pleiochaeta root rot of lupins. Brown leaf spot is considered to be the most widespread foliar lupin disease in Australia. Severe outbreaks of brown leaf spot can cause total crop failure, but more often the disease reduces potential yields by 10-15 per cent. Implementing management strategies is essential to protect lupin crops as there are no treatments available post sowing for *Pleiochaeta setosa*.

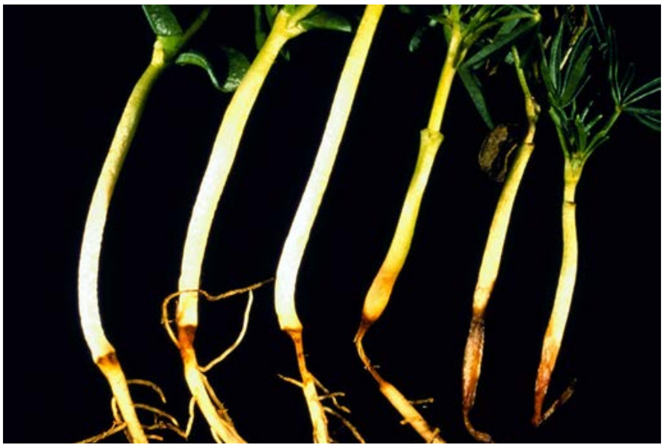


Figure 12.1. Typical root rot symptoms caused by Pleiochaeta setosa. *Note girdling of taproot by lesions.*

Figure 12.2. Typical brown leaf spot leaf lesions. These irregular shaped, brown spots are caused by Pleiochaeta setosa *infection.*

What to Look For

Pleiochaeta setosa can cause both a root rot and foliage infection and can infect lupins at all stages of growth though seedling infection has the greatest impact on yield.

Pleiochaeta Root Rot

In the paddock wilted, weak or dying seedlings can be scattered throughout and will reduce stand density, plant vigour and yield. Incidence will be worse in paddocks with a close lupin rotation.

Plants will germinate normally, but severely affected seedlings will wilt and die, displaying dark-brown or black lesions on the taproot that causes the root to rot (Figure 12.1). Less affected seedlings are weaker and smaller than healthy plants and root lesions can strip off the outer layer of tap roots that allows nodulation. After the 6 to 8 leaf stage the taproot thickens becoming less susceptible to infection. However, the finer lateral roots are susceptible for longer, which can result in reduced lateral root growth.

Brown Leaf Spot

Infected cotyledons initially develop dark brown spots and rapidly become yellow and drop off. Leaves develop discrete dark brown spots initially that eventually expand and take on a net-like appearance (Figure 12.2). Later, they can become distorted and reduced in size and under severe infection will drop off causing partial to complete defoliation (Figure 12.3).

On stems, brown flecks may appear which can develop into large brown-black cankers which kill the stem above the infection point.

Pods, especially those closer to the ground may develop larger brown lesions, resulting in seed infection. Stem and pod infections are usually associated with leaf infection in the upper canopy.

Disease Cycle

The pathogen is carried over from one season to the next on previously infected plant material, in infested seed or as spores on the soil surface. Cultivation can incorporate spores into the surface layer of soil where they remain dormant over summer. Spores can survive through non-lupin crops, but spore densities decline over time. When the next lupin crop is sown, soil-borne spores germinate and infect the roots of lupin seedlings, causing Pleiochaeta root rot. Spores that have survived on the soil surface are splashed upwards by rain droplets, infecting leaves and stems and causing brown leaf spot; thus, continuing the disease cycle.

During the growing season large numbers of spores are produced when diseased leaves fall onto the soil surface. These spores start new infections through rain splash onto healthy foliage within a short period of time (4–5 days).

Seed-borne infections are important for dissemination of the pathogen over long distances and are responsible for initial infection in clean paddocks that are isolated from other lupin crops. Severely affected pods can contaminate seed lots. Once infection is established within the crop, secondary infection of other plant parts can occur by splash dispersal of fungal spores during rain (Figure 12.4).

Management

Brown leaf spot and root rot can be effectively controlled when an integrated approach to disease management is implemented. This involves using a number of strategies including crop rotations, seed dressings, resistant varieties and retaining cereal stubble.

Variety Selection

Variety selection is also an important management strategy, by sowing resistant varieties. New narrow-leaf lupin varieties (*Lupinus angustifolius*) have been released with resistance to Pleiochaeta root rot and brown leaf spot. Broad leaf or Albus lupin (*Lupinus albus*) varieties are available with tolerance to brown leaf spot but can be susceptible to root rots under wet conditions and therefore, are limited to well-drained soils.

Paddock Selection

Crop rotation is an important management strategy as the number of Pleiochaeta spores in the soil is reduced by half for every year that a non-lupin crop or pasture is grown in the rotation. Reduced or minimum tillages operations reduce the incorporation of spores into the rooting zone of the soil profile. Long rotations are important so that lupin stubble will be decomposed before the next lupin crop is sown; avoid planting lupins in paddocks adjacent to lupin stubble.

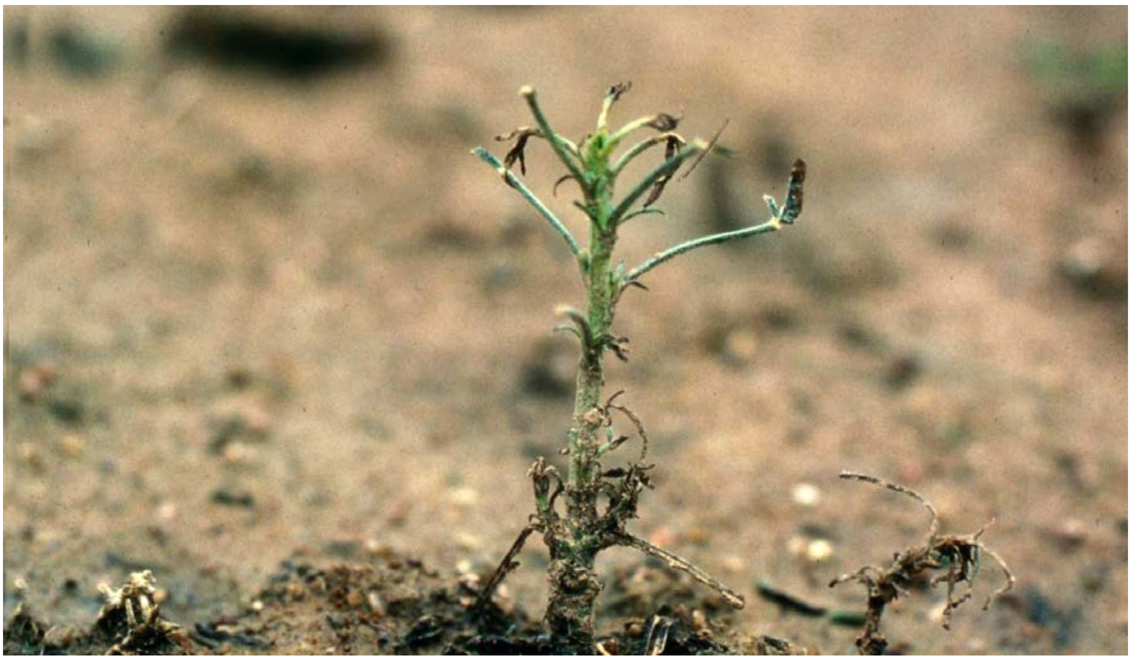
Seed Treatment

Another important method for controlling *Pleiochaeta setosa* is to apply a fungicide seed dressing (containing ipodione or procymidone), although this only suppresses the disease and does not provide complete control, but it will reduce the transfer of the disease to the seedling and can reduce leaf drop by 50 per cent.

Sowing

Deeper sowing places the emerging roots of lupins below the spores reducing the chances of Pleiochaeta root rot. Sowing lupins into cereal stubble will reduce rain splash of spores onto lupin plants. The only other known host for brown leaf spot is serradella, a low yielding pasture legume which is not common in Victorian lupin areas.

Figure 12.3. A badly defoliated lupin seedling. Leaves have dropped off due to severe infection by Pleiochaeta setosa*.*



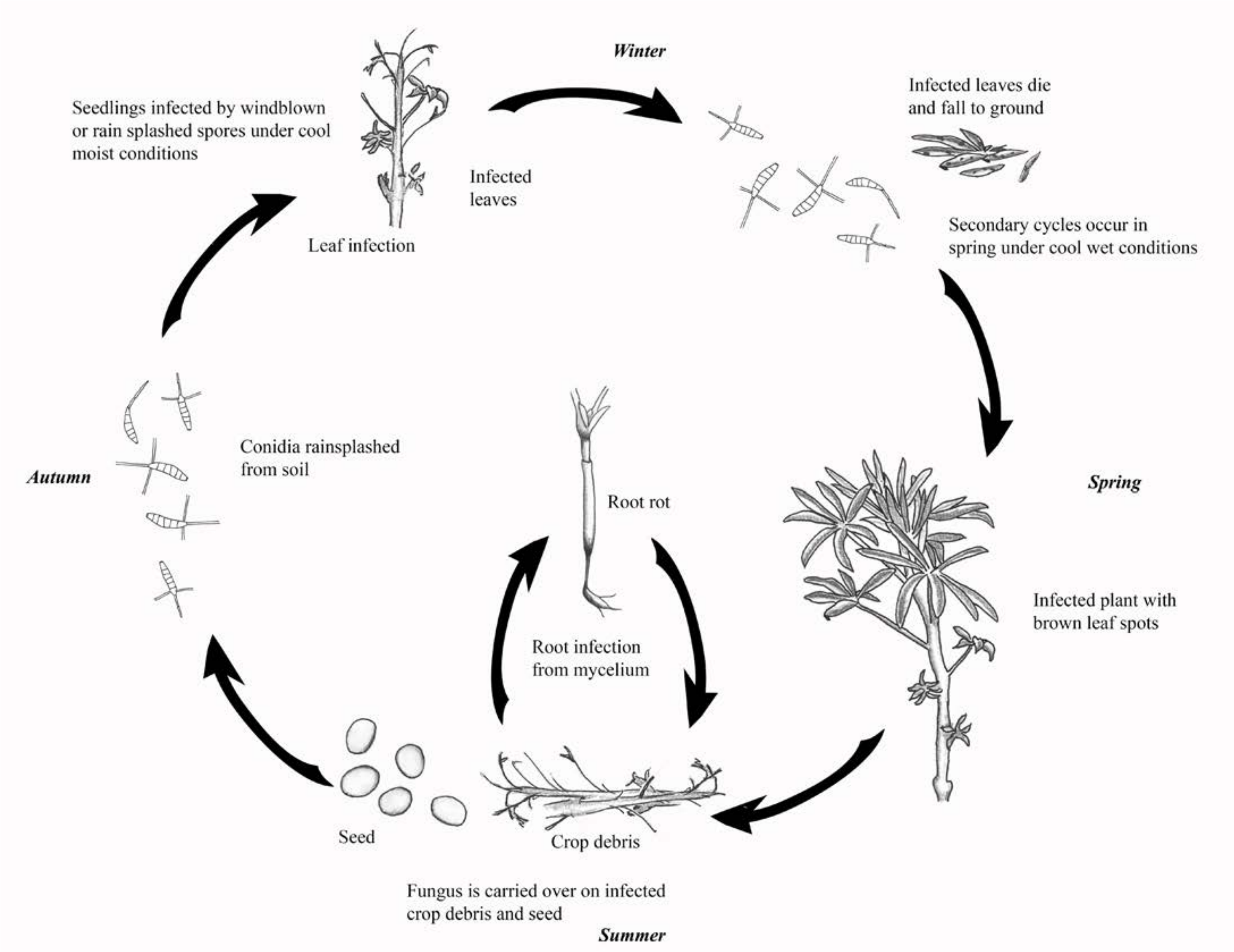


Figure 12.4. Infection cycle of the fungus Pleiochaeta setosa. *Illustration by Kylie Fowler.*

PHOMOPSIS STEM AND POD BLIGHT OF LUPINS

Phomopsis is caused by the fungus *Diaporthe toxica*. Infection can cause minor crop losses; however, the major impact of infection is the production of a mycotoxin (phomopsin) in mature lupin stems. The toxin can cause sickness or death (lupinosis) of stock that graze infected lupin stubble or seed.

What to Look For

The fungus can infect stems, leaves, pods and seed of lupins. Prematurely dying plants after pod set can be seen in crops and are found particularly in parts of the paddock that are stressed by drought, frost or herbicides.

Symptoms usually appear on senescing lupin stems and are the appearance of dark purplish lesions that bleach with age and contain black fruiting bodies and can cause plants to lodge (Figure 12.5). The appearance of disease symptoms while plants are green is uncommon. Infected seedlings develop deep- yellow to brown, irregular shaped lesions on their stems below the cotyledons. Severe lesions may girdle the stem and kill the plant. Sometimes, yellow to brown blotches are visible on the leaves and stems of older plants (Figure 12.5), but most infected plants show no disease symptoms until late in the season at senescence. The surface of green pods can become 'slimy' and mature pods may be shrivelled with reddish-tan to black lesions.

Pod lesions can lead to infected seeds which appear as either normal or are discoloured light yellow to reddish-tan. Web-like grey mould of the fungus may be seen on the seed coat and inside the seed pod.

The disease will most likely be seen on lupin stubble. Small black fruiting bodies develop, often after summer rain which stimulates growth of the fungus and the production of toxins (Figure 12.6 and 12.7). Once this occurs care should be taken when grazing stubbles for risk of livestock poisoning.

Disease Cycle

The fungus can survive on lupin stubble and seed. On stubble, the fungus can remain viable for several years. The disease usually becomes established when spores produced on old lupin stubble are carried by wind and rain into new crops. Infection can occur at any stage of plant growth if conditions are favourable for the disease.

Sowing infected seed may give rise to infected seedlings. Sometimes these develop severe stem lesions and die shortly after emergence. Plants that do survive often lack vigour and may lodge. Occasionally spore producing lesions form on infected plants while they are still green, often following a period of moisture stress.

Management

Prolonged rainfall or high humidity in late spring and summer can favour the pathogen and some toxicity may still develop requiring care to be taken when grazing occurs.

Paddock Selection

Crop rotation is an important management strategy and increasing the break between lupin crops allows weathering and breakdown of infected stubble, reducing disease inoculum. Don't sow lupins in the vicinity of old infected lupin stubbles.

Infected crop residues can be destroyed by deep ploughing or burning.

Variety Selection

In areas where lupinosis has been reported, only Phomopsis resistant lupin varieties should be grown (Table 12.1). Variety selection is an important management strategy and an effective way of reducing phomopsis. Current varieties have moderate levels of resistance to both stem and pod infection.

Seed Treatment

Use disease-free seed.

Figure 12.5. The early formation stages of a Phomopsis stem lesion on albus lupin. (Photo: Kurt Lindbeck NSW DPI)

Figures 12.6. and 12.7. Black fungal fruiting bodies are embedded in infected lupin trash after harvest

EXOTIC TO VICTORIA AND NEW SOUTH WALES

EXOTIC: ANTHRACNOSE OF LUPINS

Note: *This disease is present in Western Australia and South Australia, but not Victoria.*

Anthracnose, caused by the fungus *Colletotrichum lupini*, is a highly destructive disease of lupins. The disease can cause complete crop losses in susceptible varieties. Anthracnose was first detected in Western Australia and South Australia in lupin crops in 1996 but the disease has not been detected in Victoria to date. In 2016, Anthracnose was detected in a small number commercial lupin crops in southern NSW. Restrictions remain in place on the infected properties and surrounding properties. Widespread surveys of lupin crops across NSW in 2017 did not detect any further spread of the disease.

Lupin growers and commercial agronomists are urged to monitor lupin crops for this disease in Victoria and New South Wales.

What to Look For

Symptoms of the disease include a distinct bending and twisting of stems into a shepherds crook. The bending of stems is due to the formation of lesions within the crook of the bend causing collapse down one side. Within the lesion are bright pink/orange spore masses that spread the disease within the crop (Figure 12.8). Lesions can also later form on developing pods. Symptoms become most obvious when crops enter the reproductive phase and start flowering and podding. The disease attacks the soft plant tissue at the growing points (including stem tips, flowering spikes and pods) and works downwards into the crop canopy (Figure 12.9 and 12.10). Anthracnose will develop in patches or 'hotspots' within the crop. As the disease is spread through rain-splash of spores, patches of deformed plants will form within the crop as the disease spreads following rainfall events.

Pods develop lesions similar to stems and are often twisted and distorted. Pod infections can result in complete loss of pods or production of infected seed. Infected seeds can be malformed, have brown lesions, fungal mycelium on the seed surface, or have an occasional pink spore mass (Figure 12.11). Seeds can also be infected without any visible symptoms.

Disease Cycle

The disease is specific to lupin species only and does not affect any other pulse species including field pea, faba bean, chickpea or lentil.

The disease survives on old lupin stubble, as well as in or on infected seed. The pathogen will not survive in the soil in the absence of stubble residue.

The fungus can survive for up to two years on infected seed. Infected seed that is sown will produce infected seedlings which will quickly produce lesions on the root, hypocotyl, cotyledons, leaf petioles or stems (Figure 12.12). These lesions produce an abundance of spores that can be splashed onto surrounding healthy plants by rain and establish the disease in new and surrounding crops (Figure 12.13).

The fungus can survive over summer on infected stubble but is not regarding as a significant source of inoculum compared to infected seed. Rain stimulates the pathogen and spores produced on the old stubble can infect new crops through rain-splash and direct contact with new season or self-sown lupins.

Figure 12.8. Stem infection caused by Botrytis. Note fluffy, grey spore mass covering lesion. (Photo: Kurt Lindbeck — NSW DPI)

Figure 12.9. Early formation of an Anthracnose stem lesion. Note the bright pink/orange spore mass forming within the lesion. (Photo: Kurt Lindbeck — NSW DPI)

Figure 12.10. Typical shepherds crook symptom due to Anthracnose. The formation of lesions on one side of the stem leads to collapse of the stem. (Photo: Kurt Lindbeck — NSW DPI)

Figure 12.11. Lupin seed heavily infected with anthracnose (Image: DAFWA, www.agric.wa.gov.au).

Figure 12.12. Anthracnose seedling infection (Image: DAFWA, www.agric.wa.gov.au)

Figure 12.13 Formation of patches of albus lupin plants affected by anthracnose. (Photo: Kurt Lindbeck — NSW DPI)

Management

Do not move vehicles or equipment from an infected paddock to uninfected areas without thoroughly washing them down.

If you walk through an anthracnose infected lupin crop, wash all clothing and sterilize hands and boots by spraying with commercial bleach (2 per cent). Early detection can assist in containment of the disease if found. Growers should closely monitor all of their lupin crops for symptoms of anthracnose.

Seed Selection

Infected seed is the primary means of survival and transfer of the disease. Sowing clean seed is the best management tool for avoiding crop infection. Avoid sowing seed from South Australia and Western Australia where anthracnose is known to occur. A commercial seed test is available from AGWEST plant laboratories, Western Australia (Ph. 08 9368 3721).

Paddock Selection

Ensure at least a two-year break (preferably longer) occurs between lupin crops within the same and adjacent paddocks. Avoid sowing new season lupin crops adjacent to last year's lupin stubble.

Variety Selection

Growers are advised to select varieties with moderate resistance. Narrow-leaf varieties Wonga, PBA Jurien and PBA Barlock are Resistant (R) whilst PBA Gunyidi (MRR) and Mandelup (MR) are slightly more susceptible. All other narrow-leaf and albus lupin varieties are susceptible to anthracnose. Avoid planting ornamental or Russell lupins which have been found to carry anthracnose in Australia in the past. These lupins should not be grown in gardens on properties where lupins are grown. Varieties of narrow-leaf lupins differ in their susceptibility to anthracnose.

Fungicides

Disease transmission from infected seed can be reduced with the use of a fungicide seed dressing containing thiram.

Table 12.1. Lupin disease guide summary

DISEASE	ORGANISMS	SYMPTOMS	OCCURRENCE	HOSTS	CONTROL
Brown leaf spot	*Pleiochaeta setosa*	Dark spots on leaves and pods, leaves drop off, lesions may girdle stem	Very common but losses usually minor in dry areas, yield loss can be significant in cool damp areas	Spores in soil and lupin trash, rain-splash and wind blown	Fungicide seed dressings, crop rotation, variety selection, early sowing
Pleiochaeta root rot	*Pleiochaeta setosa*	Browning and rotting of tap and lateral roots, seedling plant death	Serious reduction in lupin plant density and vigour	Spores in soil infecting roots usually at seedling stage, spread also by rain-splash	Rotation minimum 4 years between lupins, sowing 4-5 cm deep to avoid spore layer, fungicide seed dressings
Rhizoctonia	*Rhizoctonia* spp.	Bare patches in crop, spear tipped root ends, hypocotyl rot and stain	Can be severe in isolated patches, reduces stand density, favoured by minimum tillage, wet soils and mild conditions	Soil borne infection on wide host range, survives as fungal fragments in soil and plant debris	Tillage prior and during sowing, rotation has no effect, increased seeding rate
Anthracnose	*Colletotrichum lupini*	Stems bend over, sticky dark brown lesions in crook of bend, pods and leaves above crook twist and deform, dark lesions with pale centres on leaves, stems and pods	Severe infections can result in complete crop failure	Spores surviving in soil are transported by vehicles, machinery, animals and people, spread in crop by rain-splash and wind	Clean seed and machinery, 4-year break between lupins, resistant varieties, fungicide seed dressings reduce seedling infection
Cucumber mosaic virus	Virus	All growth after infection is dwarfed, leaflets are yellowed and bunched	Early widespread infection severely reduces yield. Minor infections prevent use of harvested grain as seed	Seed borne infection in narrow leaf lupin, aphids transmit the disease within a crop	Sow clean seed, use a seed test, high sowing rates and cereal barriers around crops reduce aphid transmission
Bean yellow mosaic virus	Virus	Brown streaks on stem, shepherd crook, pods blackened and flat, plants wilt and die	Occurs in all lupin growing areas. Can be severe in higher rainfall areas	Seed borne in albus lupin, aphid spread in crop, many host species	Sow virus free seed. High plant density, cereal barrier

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/crop-variety-guides

NVT website

nvt.grdc.com.au

Seed Health Testing in Pulse Crops

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals/seed- health-testing-in-pulse-crops

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf

www.pulseaus.com.au/growing-pulses/crop-protection-products

Pulse Australia

www.pulseaus.com.au

FOLIAR DISEASES OF VETCH

Author: Dr Joshua Fanning (Agricuture Victoria) and Dr Kurt Lindbeck (NSW DPI)

INTRODUCTION

Vetch diseases can cause significant grain and biomass yield losses in addition to affecting the palatability for stock. Grain yield losses of 26 per cent were observed in trials affected with Ascochyta blight and Botrytis grey mould in Nhill during 2020. Given the versatility of vetch as a crop and the disease management practices that can be utilised, it is always important to keep the end use of the crop in mind (i.e. manured, grain, hay or grazed) as this will dictate the economic viability of control options.

There is minimal research into integrated disease management and epidemiology in vetch. Therefore, this chapter has been written with the current knowledge we have and adapting knowledge from similar pathogens in other pulse crops.

Figure 13.1. and Figure 13.2. Ascochyta lesions on vetch leaves (Photo: Joshua Fanning — Agriculture Victoria)

ASCOCHYTA OF VETCH

The fungal pathogen *Ascochyta viciae-villosae* causes Ascochyta blight of vetch. Ascochyta blight affects vetch crops early in the season with cooler wet conditions favouring disease development. When temperatures increase and the canopy dries out later in the season, visual symptoms of Ascochyta blight reduce. This is thought to be due to the infected leaves dropping off and the plant growth increasing, reducing the overall percentage of infected leaves.

What to look for

Ascochyta blight appears as light-grey to white coloured lesions (spots) which are initially light-grey to white but become tan with a dark brown margin (Figures 13.1 and 13.2). The centres of the lesions become speckled with pycnidia (tiny, dark fruiting bodies) (Figure 13.1). The presence of pycnidia is the best way of identifying Ascochyta blight lesions from those caused by other diseases such as Botrytis grey mould or Stemphylium blight. Ascochyta blight is often mistaken for other physiological conditions, such as a physiological reddening (Figure 13.3). The cause of physiological reddening is not known.

All above ground parts of vetch plants can be affected by Ascochyta blight including leaves, pods and stems. Symptoms may appear on plants from the seedling to mature stages.

Disease Cycle

Ascochyta blight can carry over from one season to the next either through the seed or infested stubble from previous diseased crops (Figure 13.4). The pathogen may also infect new crops when spores from infected stubble are carried by the wind from old vetch paddocks. Infection can occur at any stage of plant growth; however, moisture is essential. Cool, wet weather promotes sporulation, spore dispersal and infection. Secondary spread within crops occurs when spores produced on diseased plants are carried by wind and rain-splash onto adjacent plants. Rainfall late in the season provides ideal conditions for pod infection, which can result in seed infection and discolouration.

Management

Seed Selection

Ascochyta blight can carry over with infected seed which will reduce seedling vigour and potentially cause reinfection. Avoid sowing seed that came from crops that had visible Ascochyta infection on the pods.

Paddock Selection

Ascochyta viciae-villosae carries over from season to season in infected crop residues. Avoid planting vetch crops in the same paddocks or adjacent to previous vetch crops to minimise disease carry over from the previous crops. Allow the previous stubble to break down completely and preferably an additional one-year break before crops vetch is planted in the same paddock.

Variety Selection

Grow vetch varieties with the best resistance ratings. There are a range of varieties available to growers and checking the latest varietal ratings will help you develop an integrated disease management plan to reduce yield losses due to Ascochyta blight.

Fungicides

There are more foliar fungicides becoming registered for use on vetch crops to prevent or reduce disease symptoms. The economics of using these fungicides has not been well established. It is important to check product registrations and withholding periods, especially when the vetch crop is to be consumed by livestock.

Fungicides should always be applied according to label directions, ensuring the key points of spray application timing and frequency are observed as well as grazing and harvest withholding periods.

Figure 13.3. Physiological reddening in vetch which is not associated with disease (Photo: Joshua Fanning — Agriculture Victoria)

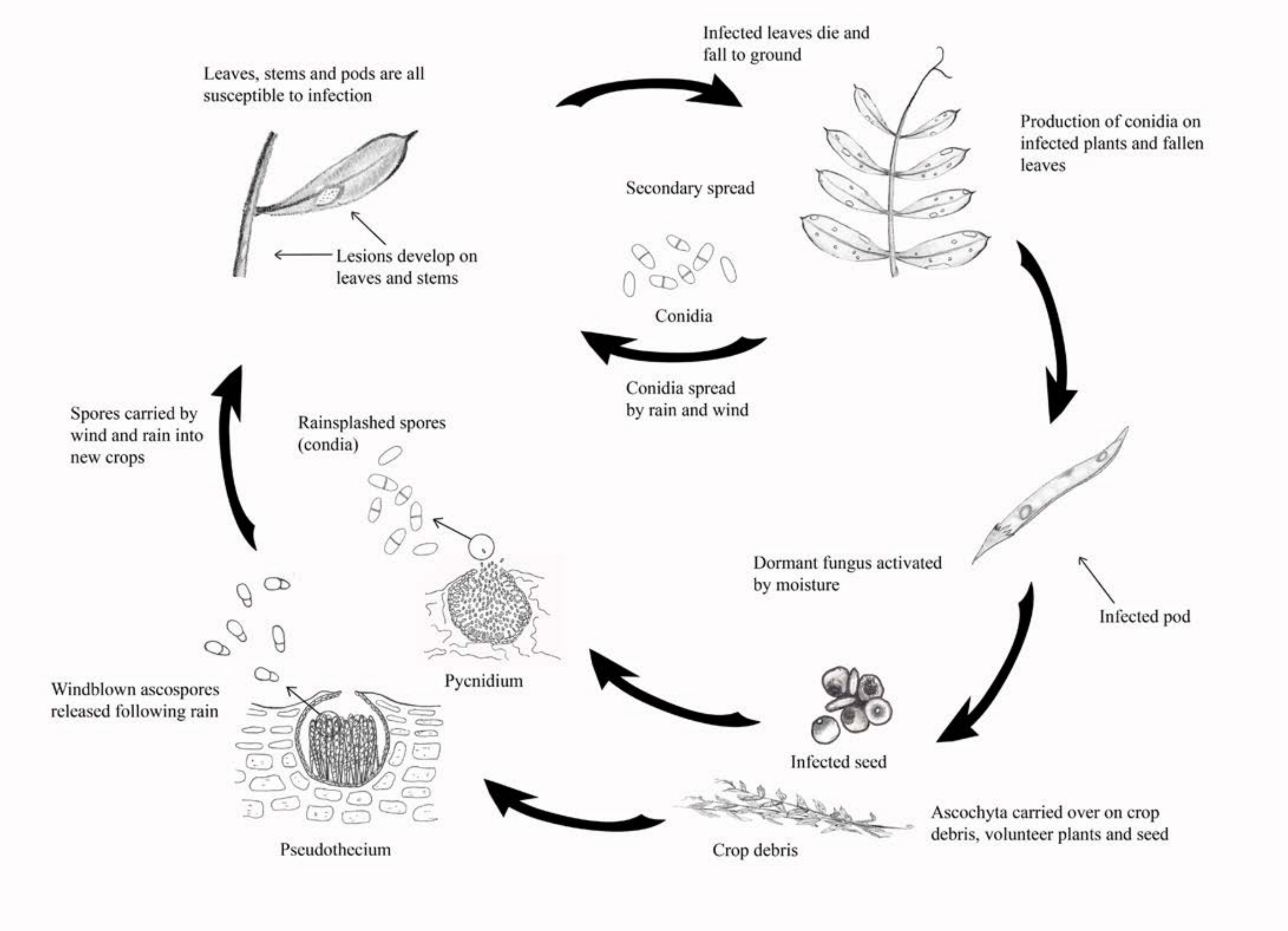


Figure 13.4. Disease cycle of vetch Ascochyta blight. Illustration by Kylie Fowler

BOTRYTIS GREY MOULD OF VETCH

Botrytis grey mould of vetch is a foliar disease caused by the fungal pathogens *Botrytis cinerea* and *Botrytis fabae*. Botrytis grey mould (BGM) of vetch is a significant risk to both grain and hay yield and quality losses especially if crops are sown early. The purpose of growing vetch is usually to have large canopies/biomass which in turn intensifies the disease risk with the canopy micro-climate ideal for disease progression.

What to look for

The disease can infect all above ground parts of the vetch plant, including leaves, stems, flowers and pods. The first symptoms are discrete greyish-brown lesions on the lower leaves of the plant. However, no black fruiting bodies are produced within the lesions (Figures 13.5 and 13.6). Infected leaves can become covered with a fluffy layer of grey mould toward the base of the plant (Figure 13.7). Stem lesions will appear light-brown or bleached and can be covered in grey, mouldy growth (Figure 13.8). The mouldy growth consists of spore masses that can quickly spread to infect surrounding plants. Clouds of spores can visibly rise from infected plants if they are disturbed.

Often in vetch there may be no lesions present, but the first signs may be a fluffy layer of grey mould where the leaves have senesced (hayed off) due to lack of light and the fungus has colonised this material (Figures 13.9 and 13.10). This can then act as a reservoir for the disease to infect the rest of the crop.

Dark black fungal survival bodies, known as sclerotia, can develop on stems and it is these structures that survive over summer on vetch stubble and in the soil. Severely infected leaves, flowers and pods wilt and fall to the ground. Plants ripen prematurely due to infection of the lower stem. If conditions remain wet throughout spring, stems can become girdled and patches of brown dying plants appear in the crop. If the canopy dries out later in the season and there is still good soil moisture, it is possible for the crop to grow away from the infection. However, there may still be palatability issues for stock and there is a good chance of reinfection when moisture returns to the canopy.

Infected pods will fail to fill properly and will produce shrivelled seed or no seed at all. Infected seed is discoloured.

Disease Cycle

The disease inoculum readily survives on faba bean (*Botrytis fabae*) and chickpea (*Botrytis cinerea*), lentil and vetch (*B. fabae* and *B. cinerea*). The pathogens can survive on stubble residue (vetch, lentil, chickpea or faba bean), in the soil as sclerotia, or can be carried on infected seed (Figure 13.11). When seed infected by these fungi are sown seedling blight will occur soon after crop emergence, reducing plant populations. Masses of spores are produced on infected plants which can then spread onto surrounding plants by wind and rain-splash to begin new infections.

Symptoms of grey mould appear more commonly in early spring following canopy closure. Dense crop canopies combined with warm, wet conditions in late winter and early spring favour the development and spread of the disease. Often symptoms of BGM first appear in double sown areas of the crop.

Moisture within the crop canopy is essential for infection which is more likely in high biomass canopies. Vetch crops are usually sown before most other crops developing high biomass canopies, and therefore have a higher risk of developing BGM. Pushing the sowing window earlier or sowing at high seeding rates will further increase the biomass and therefore the risk of BGM developing. The disease usually starts off affecting lower leaves and the base of the stem. Prolonged wet conditions during the growing season can cause the disease to progress higher up the plant, subsequently affecting pods.

Figure 13.5. First symptoms of Botrytis grey mould in vetch showing greyish-brown lesions with no pycnidia (black fruiting bodies within the lesion).(Photo: Joshua Fanning — Agriculture Victoria)

Figure 13.6. First symptoms of Botrytis grey mould in vetch showing greyish-brown lesions across leaves lower in the canopy.(Photo: Joshua Fanning — Agriculture Victoria)

Management

Although most vetch varieties are susceptible to BGM there are several management practices which can be utilised to reduce disease severity in vetch crops.

Cultural Practices

Crop rotation

As the same pathogens cause BGM in vetch, faba bean, lentil and chickpea this needs to be considered when planning rotations to allow sufficient time for stubble breakdown between affected crops. This time will vary between rainfall zones. Allow the previous potentially infested stubble to break down completely and ideally allow an additional one-year break before vetch is planted in the same paddock.

Time of sowing

Time of sowing can help to determine when canopy closure occurs which can impact the effectiveness of fungicides. If crops are sown too early and not grazed, canopy closure can occur early, not allowing foliar fungicide penetration into the crop. If canopy closure occurs too early in winter, the fungicide application at canopy closure may not protect the crop when environmental conditions favour rapid disease development when BGM starts to spread in early spring.

Grazing

Grazing may open the canopy to reduce the canopy humidity and thus reduce the disease risk. This may be particularly relevant in early sown crops.

Variety Selection

There is limited variation in resistance within current vetch varieties and there are currently no varieties resistant to BGM. Check the latest pulse disease ratings for the up to date ratings.

Fungicides

The use of foliar fungicides can be expensive, and in a crop which is often used as a manure or grazing crop, fungicides may not be warranted.

Due to the susceptibility of vetch varieties, fungicides will likely be required to prevent disease in vetch crops if they are to be cut for hay or harvested for grain. In susceptible crops, preventing BGM is very important as it is a very aggressive disease and can spread quickly across a paddock. Therefore, a preventative disease management program is better than a curative program. A foliar fungicide applied just prior to canopy closure to prevent disease development is the most effective timing. Multiple fungicides may be required in vetch due to the early sowing. However, it is always important to consider the end use of the crops and only apply fungicides where it is essential to reduce the chance of fungicide resistance developing.

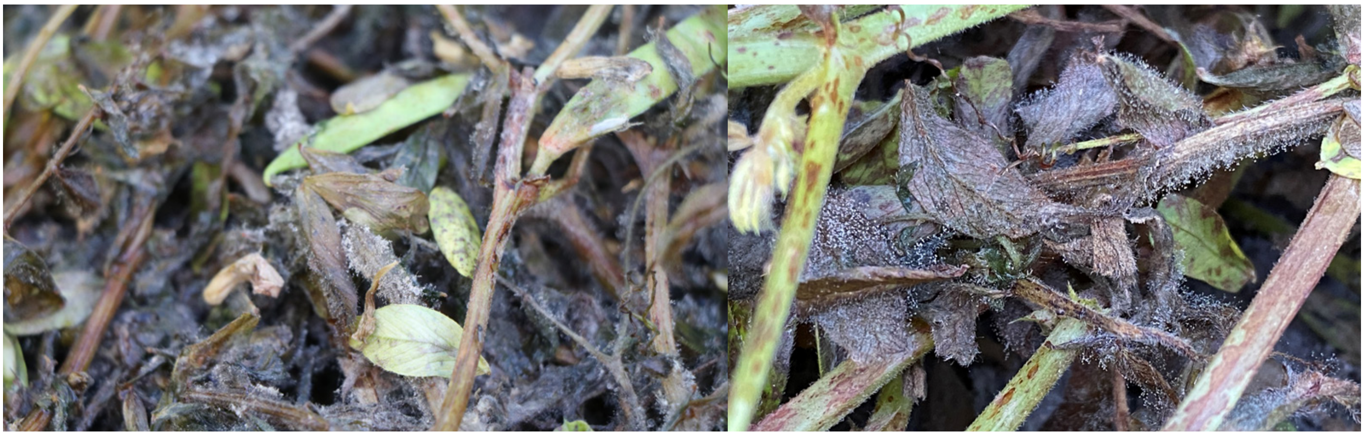
In other crops, some newer released fungicides have provided longer protection against disease and may also provide longer protection in vetch. In conducive disease years, multiple fungicides may be required. It is important to check product registrations and withholding periods, especially when the vetch crop is to be consumed by livestock.

Fungicides should always be applied according to label directions for use, ensuring the key points of spray timing and frequency are observed as well as grazing and harvest withholding periods.

In Victoria, some fungicides are known as ‘restricted use’ chemicals. Chemical licensing is required to use these chemicals. To find out more information about restricted use chemicals and chemical licensing requirements, please visit: agriculture.vic.gov.au/chemicals

Figure 13.7. Infected leaves with a fluffy layer of grey mould (Photo: Joshua Fanning — Agriculture Victoria)

Figure 13.8. Infected stems with a fluffy layer of grey mould (Photo: Joshua Fanning — Agriculture Victoria)



Figures 13.9. (left) and 13.10. (right) Senesced (hayed off) vetch leaves due to lack of light covered in a fluffy layer of grey mould (Botrytis grey mould), close to the ground (Photos: Luise Fanning — Agriculture Victoria and Joshua Fanning — Agriculture Victoria)

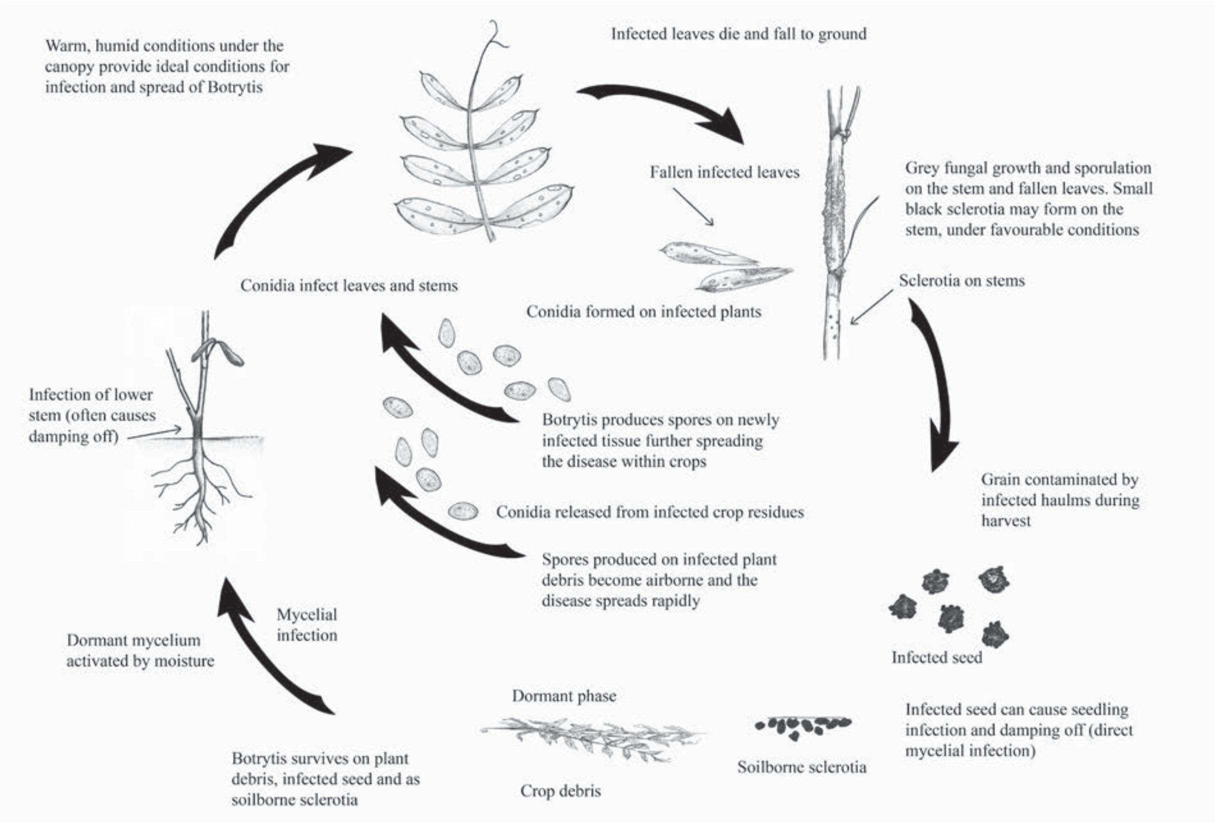


Figure 13.11. Disease cycle of vetch Botrytis grey mould. Illustration by Kylie Fowler

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Pulse Disease Guide

agriculture.vic.gov.au/pulse-disease-guide

Agriculture Victoria AgNotes Series

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals

Victorian Crop Sowing Guide

grdc.com.au/victorian-crop-sowing-guide

Other state crop summaries

grdc.com.au/resources-and-publications/all-%20publications/crop-variety-guides

NVT website

nvt.grdc.com.au

Seed Health Testing in Pulse Crops

agriculture.vic.gov.au/agriculture/pests-diseases-and- weeds/plant-diseases/grains-pulses-and-cereals/seed-health-testing-in-pulse-crops

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/growing-pulses/crop-protection-products

Pulse Australia

www.pulseaus.com.au

DISEASES OF CANOLA

Authors: Dr Steve Marcroft (Marcroft Grains Pathology) and Dr Angela van de Wouw (University of Melbourne)

INTRODUCTION

In Australia, canola can be infected by a number of pathogens ranging from root rots to leaf disease, crown rots and stem infections (Table 14.1). As with all diseases their incidence and severity are dependent on plant susceptibility, presence of the pathogen and favourable climatic conditions. Generally, fungal disease such as Blackleg and Sclerotinia are more damaging in higher rainfall regions. However, if unseasonably high rainfall occurs in lower rainfall regions, these areas may also experience high disease levels.

Disease control varies for each pathogen though, generally, variety resistance, crop management practices and fungicides are used either in isolation or combination to reduce economic losses. If growers are aware of the disease risks in their area and follow strategic management plans they should be able to adequately control most canola diseases.

Table 14.1. Common canola diseases diagnostic key

PLANT GROWTH STAGE	PLANT PART INFECTED	POSSIBLE DISEASE
Seedling	Leaves	Blackleg, white leaf spot, downy mildew
	Hypocotyl	Blackleg
	Roots	Damping off
Rosette	Leaves	Blackleg, white leaf spot, downy mildew
	Crown	Blackleg
	Roots	Damping off, blackleg, clubroot
Flowering	Leaves	Blackleg, Alternaria, white leaf spot
	Stem & Branches	Blackleg, Sclerotinia, Alternaria
	Flowers	Blackleg
	Crown	Blackleg
	Roots	Blackleg, clubroot
Podding	Stem & Branches	Blackleg, Sclerotinia, Alternaria, Powdery mildew
	Pods	Blackleg, Alternaria, Powdery mildew
	Crown	Blackleg
	Roots	Blackleg, clubroot

BLACKLEG

Blackleg is challenging to control:

- *Leptosphaeria maculans*, the causal agent of Blackleg, is a sexually reproducing pathogen that can overcome cultivar resistance genes
- Fungal spores are released from canola stubble and therefore the disease is more severe in areas of intensive canola production
- Spores are spread extensively and quickly via wind and rain splash.

Blackleg, caused by the fungus *Leptosphaeria maculans*, is the most serious disease of canola in Australia. Blackleg is most severe in regions of high canola intensity with moderate to high rainfall. Although not common, yield losses of 50 per cent and greater have been recorded. Where cultivar Blackleg resistance has been overcome, up to 90 per cent yield loss has been recorded.

What to Look For

Figure 14.1 shows the various Blackleg disease symptoms on canola. In the autumn and winter, rainfall triggers spore release from the fruiting bodies on stubble (Figure 14.1a). Within two weeks of spores landing on canola cotyledons (Figure 14.1b) and young leaves (Figure 14.1c), clearly visible off-white coloured lesions develop. Within the lesion, pycnidial fruiting bodies (dark coloured dots) form and then release rain-splashed spores which can cause secondary infections.

Once the lesion has formed, the fungus grows within the plant's vascular system to the base where it causes the crown of the plant to rot resulting in a canker (Figure 14.1e). Severe canker will sever the roots from the stem (Figure 14.1f), whereas a less severe infection will result in internal infection of the crown restricting water and nutrient flow within the plant (Figure 14.1e). When no infection is present, a clear white stem is visible (11.1d).

In recent years, Blackleg lesions have commonly been seen on the upper canopy of the plant, including the flowers (Figure 14.1g-j), pods (Figure 14.1k), upper stem and branches (Figure 14.1l-n). This type of infection, referred to collectively as upper canopy infection (UCI), has become a significant yield limiting factor.

Blackleg symptoms have also been found in the plant roots; in severe cases this root infection appears to cause the entire plant to die prematurely (Figure 14.1o).

Disease Cycle

Blackleg survives on canola stubble producing fruiting bodies (pseudothecia) that contain large quantities of airborne spores; capable of travelling several kilometres. However, the majority of spores only travel a short distance (less than 500m). Timing of spore release from the stubble normally occurs approximately 3 weeks after the break of the season and is therefore dependent on autumn rainfall. Higher rainfall environments therefore often have earlier seasonal spore release, longer periods of leaf wetness and consequently increased disease severity.

The main infection period for Blackleg is from mid-May through to the end of July, this is because infection is a result of spore release in the presence of long periods of plant wetness. Consequently, if plants are at the seedling – vegetative stage from mid-May to the end of July there will be cotyledon and leaf infection. Early infection of cotyledons/leaves (up to the 6th leaf) give the fungus enough time to grow down the stem and cause severe crown canker. Therefore, if the crop is at the early growth stages during the infection period (spore release), protection of the cotyledons/leaves is essential for minimising crown canker.

Early sown crops that become reproductive (elongating and flowering) during the peak infection period (prior to the end of July) may also get lesions forming on the flowers and stems/branches. This infection is known as upper canopy infection.

After harvest the Blackleg fungus survives on the canola stubble and undergoes sexual reproduction, ready to release spores in the following growing season.

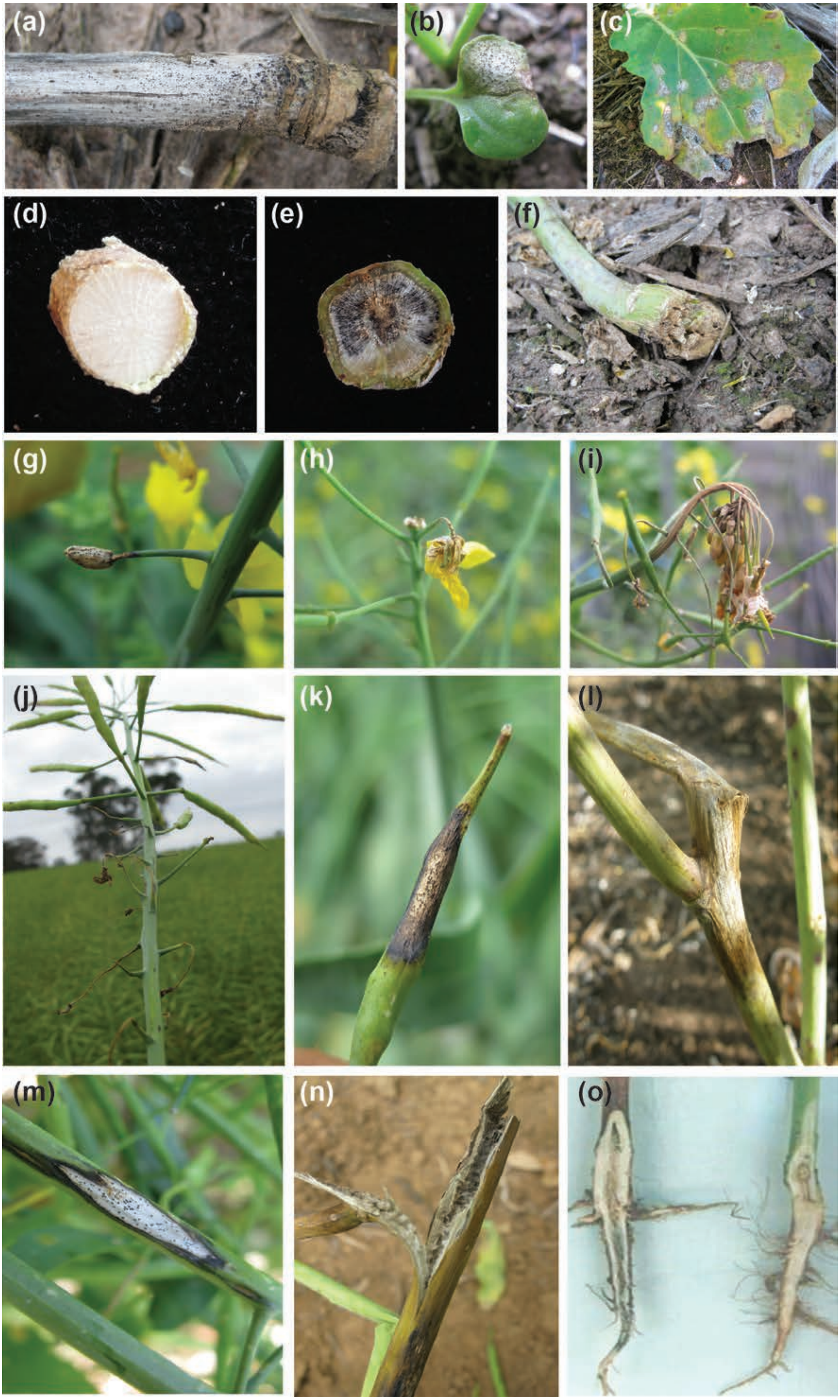


Figure 14.1. Blackleg disease symptoms caused by Leptosphaeria maculans. *Blackleg infested stubble (a) covered in fruiting bodies (black dots). Typical cotyledon (b) and leaf lesions (c) seen early in the growing season. Blackleg can infect the crown of the stem; panel (d) shows a clean stem, whilst panel (e) shows a severely infected stem which would result in yield loss. In severe cases, the stem can sever off from the roots (f). In recent years Blackleg has infected the upper canopy (panels g-n). This includes infection of the flowers (g – j), which leads to abortion of pod development; direct infection of the pods (k) as well as branches (l and m) and upper stems (n). Lastly, the roots of the plant can also be infected in severe situations (o) (Photos: Steve Marcroft – Marcroft Grains Pathology, Angela Van de Wouw – Melbourne University, Susie Sprague – CSIRO)*

Management

Management practices to control crown rot blackleg are the same for the root rot form of the disease as follows:

- Consult the Blackleg Management Guide on the GRDC website (www.grdc.com.au) for up to date ratings, resistance groups and management practices.
- Download BlacklegCM App on your iPad or tablet to use the interactive model to investigate all management options for your individual paddock. The app does not work on mobile phones.
- Monitor your crop to determine yield losses (Figure 14.2).
- Choose a cultivar with adequate Blackleg resistance for your region.
- Never sow your canola crop into last year's canola stubble, ideally leave 500m distance from this year's crop and last season's stubble.
- Use fungicides strategically to control Blackleg, economic return from fungicides is dependent on Blackleg severity. If using R rated cultivars, fungicides are unlikely to provide an economic return. Generally seed treatments and fertiliser amended with fungicide are likely to give an economic return especially if your crop is sown adjacent to the previous season's stubble. Foliar fungicides should only be used in very wet years where disease severity if unusually high, or if other management options cannot be used (e.g. sowing a lower resistance rating cultivar next to the previous season's stubble). Use the BlacklegCM App to investigate individual fungicide application scenarios.
- If your monitoring identifies high levels of internal infection and you have grown the same cultivar for three years or more, choose a cultivar from a different resistance group.

Management for upper canopy Blackleg infection:

- Monitor your crop in the spring for flower infection and at windrowing for stem, branch and pod infection (Figures 14.1-14.3). The monitoring will not help in the current season but will provide some guidance to crop management requirements for future seasons.

Figure 14.2. Cutting a plant at the crown to assess internal infection (Photo: Steve Marcroft – Marcroft Grains Pathology)

- Plan the crop flowering time. In most regions crops that commence flowering in early August will avoid most UCI symptoms. Crops that flower during June and July are more likely to be infected. Flowering time can be altered by sowing date and/or by choosing cultivars that are later flowering.
- If applying fungicide for Sclerotinia control and the fungicide is registered for both Sclerotinia and Blackleg, it is likely that the application for Sclerotinia will also provide protection against UCI. Fungicide should be applied at 30 per cent bloom which is the current Sclerotinia timing recommendation.
- Cultivars that have effective major gene resistance will not get UCI symptoms regardless of their flower commencement timing.
- The UCI BlacklegCM App is now available for phones and tablets. This app can be used to help make spray decisions for controlling UCI. However, please note that the app is being updated each year as we gain additional knowledge about this form of the disease.
- We recommend where possible, to monitor your crop at the end of the season to determine whether you did indeed have UCI (if you didn't apply a fungicide). Whilst it won't help with making decisions in the current year, it will help you understand your risk the following year.

Figure 14.3. Cutting branches to assess the number of plants with infected (black) pith as an indication of upper canopy infection (Photo: Steve Marcroft – Marcroft Grains Pathology)

SCLEROTINIA STEM ROT

The disease Sclerotinia stem rot is caused by the fungi *Sclerotinia sclerotiorum* and *Sclerotinia minor* which can occur on many broadleaf plants including canola, pea, bean, lupin, sunflower, pasture species and broadleaf weeds. Cereal crops and grass weeds do not host the disease. In Australia, the disease is highly sporadic requiring specific environmental conditions to develop. Disease incidence can vary greatly from year to year but is most damaging with prolonged wet conditions, resulting in high humidity leading up to and during flowering.

The sporadic nature of the disease and its severity make it difficult to reliably make foliar fungicide application decisions. Several forecasting tools developed overseas have been evaluated in Australia but have been found to be inappropriate due to differences in climate and length of flowering. Yield loss is often difficult to predict but can be up to 24 per cent under Australian conditions, depending on the percentage of plants infected and the crop growth stage when infection occurs. Recent research has shown that stem infection results in more yield loss than lateral branch infection. Current management options before sowing are limited to sowing clean seed, isolating canola from last year's infected paddocks and crop rotation. The use of foliar fungicides at flowering is the only post-sowing management option.

Warning Signs

A canola crop is at risk of developing Sclerotinia stem rot if it is:

- grown in a high rainfall area (especially if the crop has been sown early at high seeding rates)
- grown in low lying parts of the landscape such as the floor of valleys which stay wetter for longer than nearby hill slopes
- grown in intensive rotation with other broadleaf crop species, including summer crops of sunflower and soybean
- sclerotinia has been present within the past three years in that paddock or adjacent paddocks.

The following conditions are conducive for a Sclerotinia outbreak in canola. All three must occur for infection to take place:

- Wet conditions for at least 10 days at the soil surface in mid to late winter and temperatures of 11–15°C to germinate sclerotia and trigger spore release.
- Extended wet periods during flowering for petal infection.
- Extended wet periods during petal drop, the lodging of petals on stems and subsequent stem infection. Stem lesion development is favoured by humid/wet conditions and mild temperatures.

Figure 14.4. Disease symptoms and fruiting structures of Sclerotinia stem rot. (a) Diseased plants are visible with white bleaching of the stem. (b and c) White bleached stems characteristic of Sclerotinia infection. (d and e) Black sclerotia are formed and remain in the soil to germinate, produce apothecia which then release spores (Photos: Steve Marcroft – Marcroft Grains Pathology and Kurt Lindbeck – NSW DPI)

What to Look For

Symptoms of Sclerotinia in canola include fluffy white fungal growth on stems and bleached stem lesions (Figure 14.4). Initial symptoms are water soaked, light-brown discoloured lesions on stems or leaves that expand and become greyish-white. If a lesion completely girdles the main stem, the plant quickly wilts and dies prematurely. Infected canola plants will ripen earlier and stand out among green plants. The bleached stems tend to break and shred. In wet or humid weather, a white growth resembling cotton wool can develop on infected plant tissue.

Disease Cycle

Sclerotinia survives the summer season as a sclerotia. Sclerotia are simply very hard, dry mycelium; sclerotia have the appearance of rat droppings. With favourable moisture and temperature conditions in winter the sclerotia germinate in the soil and produce apothecia; small, golf-tee-shaped fruiting bodies, 5 to 10 millimetres in diameter. The apothecia then release airborne fungal spores. Spores of the Sclerotinia pathogen cannot infect canola leaves and stems directly. They require flower petals as a food source for infection. infected petals then drop into the canopy and lodge on leaves, leaf axils or stem branches. Under moist conditions the fungus will spread from the petal, with infection initially commencing as a tan-coloured lesion resembling a watermark. Infected plant parts wilt and turn mouldy. Leaves infected by petals may also fall and lodge further down the canopy as well as spread infection through direct contact with other plants. Stem lesions will result in the production of sclerotia within the stem, which are then returned to the soil after harvest.

Management Options – Before Sowing

Clean Seed

Sow only good quality seed that is free of sclerotia. If using ‘farmer saved’ seed for sowing it should be graded to remove any sclerotia. Carefully inspect seed before sowing. Ungraded seed used for sowing can inadvertently transfer sclerotia into the soil, which can later initiate the disease.

Crop Isolation and Rotation

Avoid sowing canola into or next to paddocks that were heavily infected with Sclerotinia in the previous three years. The spores are airborne and can be blown some distance into surrounding paddocks. Although rotation does not effectively control Sclerotinia, close rotation of susceptible crops such as lupin may increase fungal inoculum build-up. In addition, it is preferable that crops be sown on the western side or ‘up wind’ from old canola stubbles.

Management Options – After Sowing

Consider Fungicide Use

If favourable environmental conditions occur (see Warning signs) fungicides are the only available option for managing Sclerotinia stem rot after sowing. A number of products are currently registered in Australia to manage Sclerotinia stem rot of canola.

Due to the sporadic nature of the disease, it is uneconomical to apply fungicides routinely; to be effective they need to be applied before the plant becomes infected. This can be difficult as fungicides should be applied before petal infection occurs.

Research has shown that strategically applied foliar fungicides (1 or 2 applications) can be effective in reducing the level of Sclerotinia stem rot and subsequent yield loss in crops with a high yield potential and at high risk of developing the disease.

If you decide to spray, the current recommendation is to apply a foliar fungicide between 20 and 30 per cent bloom, a second foliar spray may be required 10 days later if favourable disease conditions persist. If the crop is not growing in an area prone to Sclerotinia, it is unlikely that a foliar fungicide application will be economic.

WHITE LEAF SPOT

White leaf spot is caused by the fungus *Mycosphaerella capsellae* (also called *Pseudocercosporella capsellae*). The disease has a worldwide distribution and a wide host range among cruciferous weeds. In Australia, white leaf spot commonly infects canola seedlings. It is not usually severe enough to cause yield loss.

What to look for

Leaf and stem lesions are greyish-white to light brown (Figure 14.5). Unlike Blackleg lesions, white leaf spot lesions do not contain pycnidial fruiting bodies (black dots) and usually have a more granular surface compared with the smooth surface of Blackleg lesions (Figure 14.5b). Leaf lesions often have a brown margin when they mature; they can be up to one centimetre in diameter and often join to form large irregular shaped lesions. Nutrient deficient crops have been reported to be more severely affected by the disease. In severe epidemics, infections can cause leaf death and defoliate plants.

Disease Cycle

The fungus survives on canola stubble as thick-walled mycelium. When prolonged wet weather conditions prevail autumn/winter wind-borne spores are produced that cause primary leaf lesions on canola. These initial lesions go on to produce new wind-borne spores that cause the rapid spread of the disease throughout the crop. The disease is not usually seed-borne but can be spread by infected seeds or infected debris with the seed.

Management

- White leaf spot infection is not usually severe enough to warrant control. In severe situations, fungicide applications may be warranted.
- Crop rotation and isolation from the previous year's canola stubble will reduce infection from windborne spores.
- Control cruciferous weeds and volunteer canola.
- Provide adequate nutrition to reduce crop stress.
- Pydiflumetofen (MIRAVIS®) foliar fungicide is registered for White leaf spot control. Foliar fungicide applications for early Blackleg control will also provide control against White leaf spot.

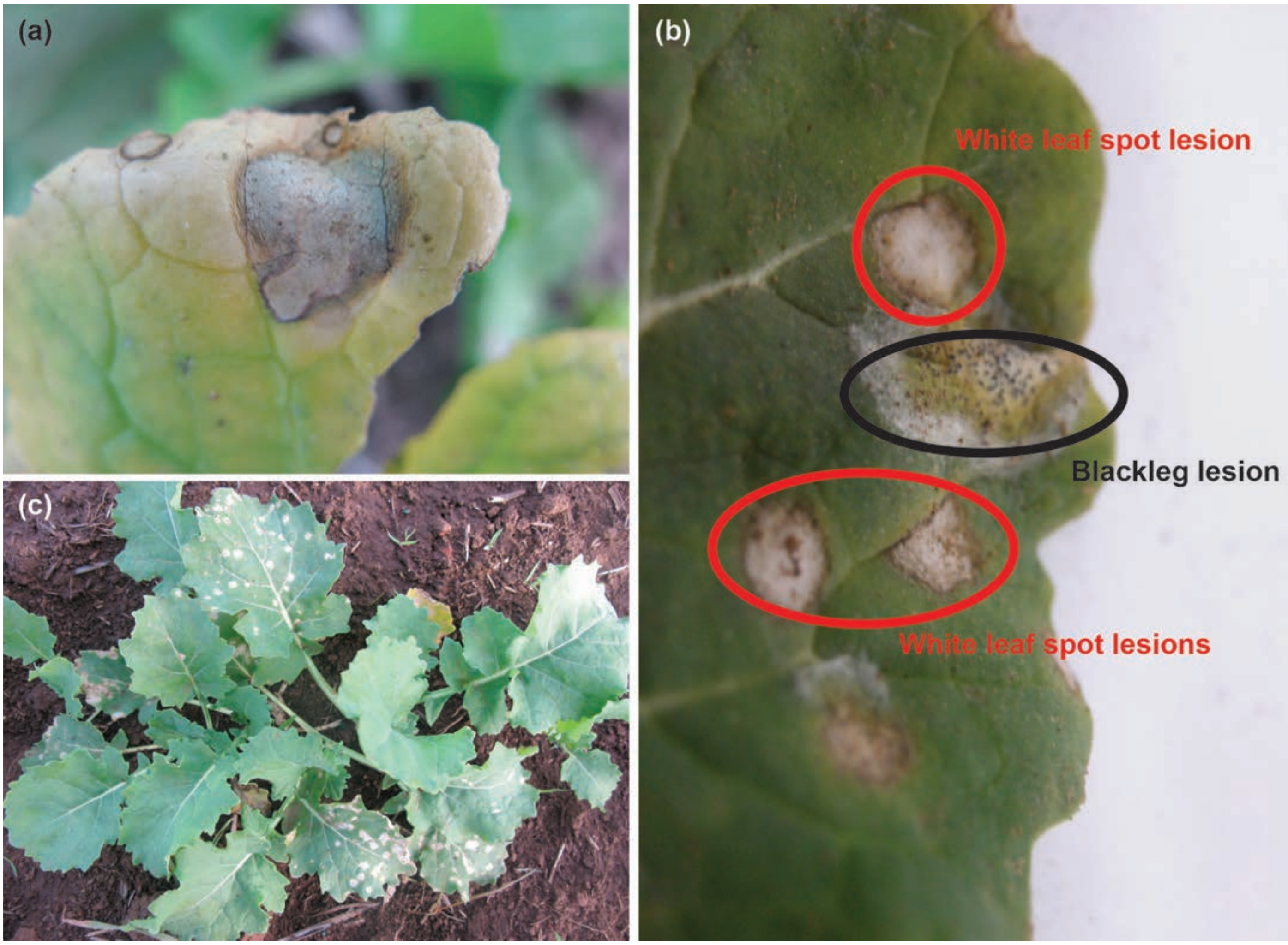


Figure 14.5. White leaf spot infection on canola leaves. (a) Typical off-white coloured lesion. (b) Typical White leaf spot lesion (red circles) and Blackleg leaf lesions (black circle). Note the White leaf spot have no small black spots (fruiting bodies). (c) Mildly severe White leaf spot infection (Photos: Steve Marcroft – Marcroft Grains Pathology)

DOWNY MILDEW

Downy mildew is a common disease of canola throughout the world and is caused by the fungus *Peronospora parasitica*. Infection occurs under cool moist conditions where leaves or cotyledons are in contact with the soil or other leaves. Although seedlings can be severely attacked by the disease, significant yield loss does not usually occur. Downy mildew is rarely found beyond the rosette stage and crops normally grow away from it with the onset of warmer weather.

What to look for

Chlorotic or yellow areas on the upper leaf surface are the first symptoms to occur. These can be seen on young seedlings when cotyledons or first true leaves are present. A white mealy fungal growth can be seen on the underside of the leaf beneath these spots. Infected cotyledons tend to die prematurely. As the disease develops, individual spots join to form large irregularly shaped blotches. These necrotic lesions may cause a large part of the leaf to dry out and the upper surface of the leaf to develop a yellow red colour (Figure 14.6).

Disease Cycle

The fungus is both soil and seed-borne and can persist in the soil for a long time. Infection is favoured by cool, wet weather and under ideal conditions, new infections can develop in as little as 3 to 4 days. The fungus is related to white rust with specialised spores (oospores) probably responsible for primary infections. Conidial spores produced on the underside of the infected leaf are then responsible for the secondary spread of the disease.

Management

- Downy mildew does not usually affect yield so control measures are not generally warranted unless plant densities are severely reduced on a regular basis.
- In areas where Downy mildew is a severe problem, fungicides containing copper as the active ingredient are registered for use in Australia.
- Crop rotation and the control of cruciferous weeds between canola crops can reduce disease severity.

Figure 14.6. Symptoms of Downy mildew on canola. (a) Chlorotic yellow symptoms characteristic of Downy mildew. (b) The underside of the lead with typical mealy white hyphal growth. (c) Early stages of Downy mildew infection. (d) Mildly severe infection of a crop (Photos: Steve Marcroft – Marcroft Grains Pathology)

ALTERNARIA LEAF AND POD SPOT (BLACK SPOT, DARK LEAF SPOT, ALETERNARIA BLIGHT)

Alternaria is usually caused by the fungal pathogen *Alternaria brassicae* and occasionally by *Alternaria brasicicola*. The severity of the disease varies between years and locations depending on seasonal conditions. The disease is favoured by warm humid conditions during spring. Yield loss is unusual and is normally associated with the shattering of infected pods. If infected seed is retained for sowing in subsequent years, seedling blight may occur (refer to damping-off section).

What to Look For

Alternaria infects all growth stages of canola plants. However, as plants mature from mid flowering onwards they are more susceptible to infection. Alternaria symptoms can be found on all parts of the plant including leaves, stems and pods. Spots on leaves and pods have a concentric or target-like appearance and are brown, black or greyish white with a dark border.

Lesions on green leaves are often surrounded by a chlorotic (yellow) halo (Figure 14.7a). Severe pod infections may cause seed to shrivel and the pods to prematurely ripen and shatter. Pod symptoms of Alternaria are similar to those of Blackleg and the two can be difficult to distinguish in the field (Figure 14.7b and c).

Disease Cycle

Alternaria spp. survive the intercropping period on infected canola stubble, on cruciferous weeds and to a lesser extent on seed. Seed infections can cause seedlings to rot (refer to damping-off section) resulting in a seedling blight that reduces plant establishment. Initial crop infections are caused by windblown spores. Spores remain intact on susceptible plants until moisture from dew or rain allows them to penetrate into the tissue and cause a lesion. These lesions produce more spores and infections can then be spread throughout the crop by either the wind or rain. Mild, humid conditions favour disease development and the disease cycle will continue throughout the season under favourable conditions. Hot and dry conditions interrupt epidemics as the absence of moisture greatly reduces spore production. Major outbreaks are not common in Australia as weather conditions are normally hot and dry throughout podding which is unfavourable for prolonged infection. However severe pod infection can occur in years when rainfall continues into late spring, especially when there is a wet harvest.

Management

- Alternaria is very common in canola crops but is not usually severe enough to warrant control.
- In Australia, there are no registered fungicide seed treatments for Alternaria.
- In areas where Alternaria is a problem, select paddocks isolated from last year's canola stubble as Alternaria spores are easily transported in wind and can spread into areas that have not had canola for several years.

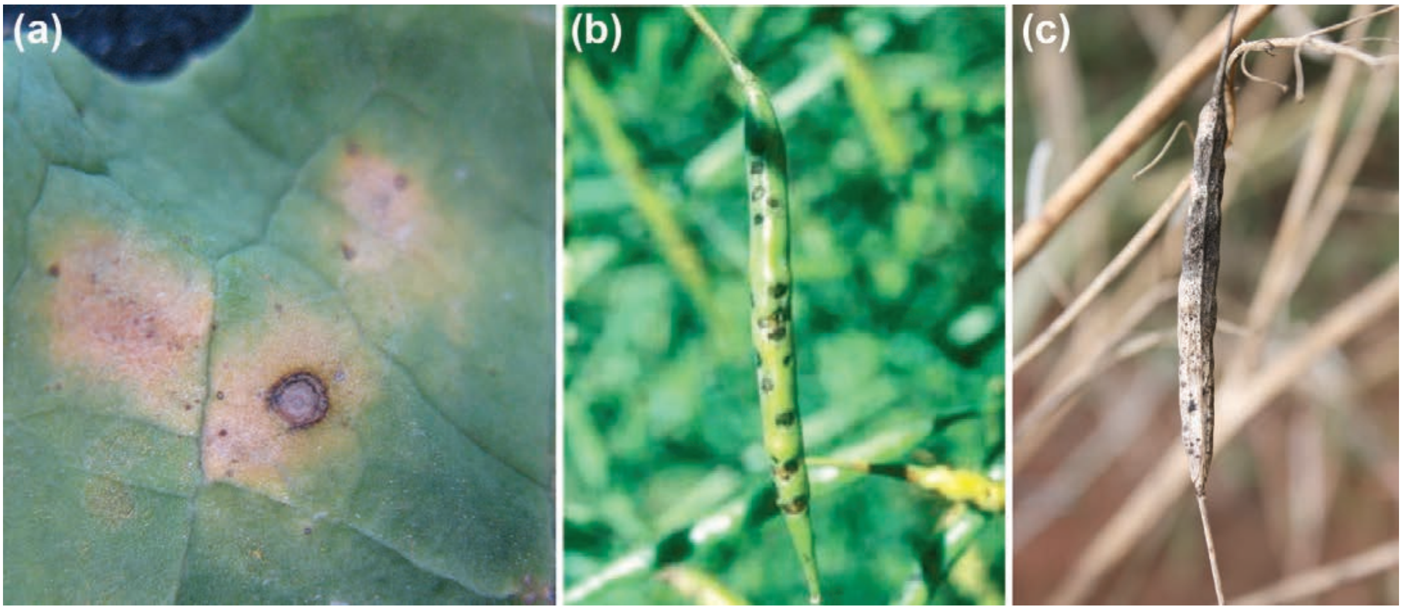


Figure 14.7. Symptoms of Alternaria on canola. (a) Alternaria lesions on the leaf (note target like rings). (b and c) Pod lesions that can lead to premature pod shattering (Photos: Steve Marcroft – Marcroft Grains Pathology)

POWDERY MILDEW

Powdery mildew, caused by *Erysiphe cruciferarum*, is a sporadic disease and occurs mostly under humid conditions in thick crops and when nitrogen nutrition is good. Warm, dry climates with cool nights that favour dew formation initiate powdery mildew infection. Over summer the fungus survives on crop residue or host weeds. Spores produced on the crop residues are dispersed by wind, rain splash or insects the following year.

What to look for

The white powdery growth visible on the plant is primarily made up of spores and mycelium. The fungal spores are rapidly spread by wind from plant to plant and can germinate and infect without the presence of free water. The fungus never invades the plant tissue and continues to grow on the surface.

Small, white powdery spots first appear on the surface of older leaves (Figure 14.8). These spots can rapidly expand in size and coalesce to form a dense, white layer that can resemble talcum powder. Whole leaves can quickly become affected. The infected area is initially white and then turns black after a period of time. Stems and pods can also become covered. Severely affected pods have smaller seeds and can affect oil quality.

Management

- Powdery mildew infection is not usually severe enough to warrant control.
- Powdery mildew is very host specific. Rotation away from Brassica species will reduce the inoculum levels.
- There are no registered fungicides or seed dressings for the control of Powdery mildew in Australia.

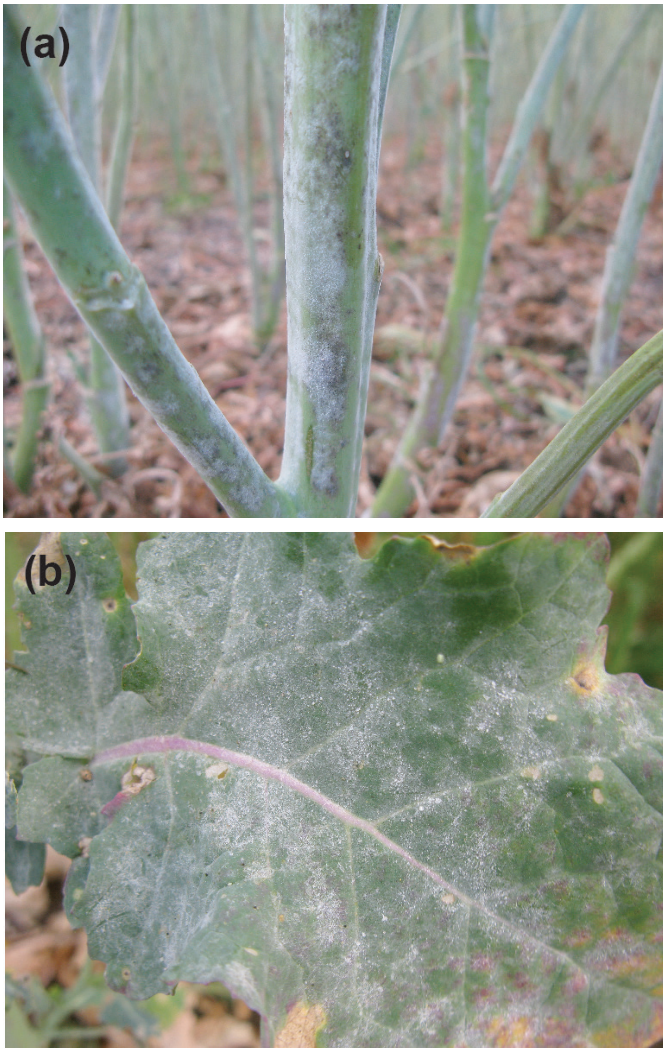


Figure 14.8. Symptoms of Powdery mildew on branches (a) and leaves (b) of canola plants (Photos: Steve Marcroft – Marcroft Grains Pathology)

DAMPING-OFF (SEEDLING BLIGHTS AND SEEDLING HYPOCOTYL ROT)

Damping-off is usually caused by the fungus *Rhizoctonia solani*. However, other fungi including *Fusarium* spp., *Pythium* spp., Phytophthora spp. and *Alternaria* spp. can also cause damping-off. Symptoms and crop management are similar for all these pathogens, so they are grouped together and referred to as 'damping-off'.

All species are common inhabitants of the soil and cause damage when conditions are not ideal for early seedling growth. Problems are usually seen when seed is sown dry, close to the autumn break (within a couple of weeks of a normal break) or if weather conditions become cool and damp. Yield loss is unusual unless plant numbers are severely reduced or patchy establishment occurs.

What to look for

Damping-off can produce many symptoms ranging from pre-emergence rot (failure of plants to emerge) to post-emergence damping-off (plants emerge and collapse at ground level) (Figure 14.9a). If affected plants survive, they are normally stunted and may flower and mature prematurely (Figure 14.9b).

Once past the seedling stage canola plants are not adversely affected by damping-off. Both pre- and post-emergent damping-off occur in patches and affected areas can spread quickly during cold, wet conditions. Leaves of plants affected by post-emergent damping-off may become discoloured, turning orange, purple and/or chlorotic. In some cases, the tap root is dark in colour and shrivelled at ground level. These symptoms should not be confused with insect damage where root or stem tissue has been removed.

Damping-off fungi are soil-borne and survive in the soil by forming resistant resting structures when no host is present. These resting structures germinate with the break of the season and the fungi grow through the soil until they find a susceptible host plant. Seeds become vulnerable to attack as soon as they begin to germinate. Once in the plant, the fungi multiply causing decay that damages or kills the seedling. Damping-off fungi are usually only able to infect young succulent tissue. At the two to four leaf stage roots of canola plants become woody enough to withstand further infections. Therefore, most damage occurs when wet and cold weather slows plant growth. Temperature and soil moisture affect disease development. Loose, cold and dry soils favour Rhizoctonia solani, while cold damp soils favour Fusarium spp. and wet, heavy soils favour Pythium spp.

Management

- Yields are only affected when plant numbers are severely reduced. If seedling loss is uniform throughout the crop, surrounding plants can often compensate by growing larger. If seedling loss is patchy and large areas die, then re-sowing may be required.
- Damping-off fungi will germinate with the opening rains of the season. Once they have germinated they are very successfully controlled by soil tillage. Therefore dry-sown or crops sown very close to the opening rains may be more severely affected. If crops are re-sown the sowing tillage will generally control the fungi.
- Maxim®XL is registered for the control of Pythium and Rhizoctonia.

Figure 14.9. (a) Symptoms of Rhizoctonia damping-off on seedling canola. (b) Infected seedlings that if survive may be stunted and flower prematurely (Photo: Steve Marcroft – Marcroft Grains Pathology)

FURTHER INFORMATION

More detailed information can be obtained from:

GRDC Blackleg Management Guide

https://grdc.com.au/GRDC-FS-BlacklegManagementGuide

VIRUSES OF FIELD CROPS

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INTRODUCTION

Plant viruses are economically important pathogens, reducing yield and quality of many agricultural crops. There are over 700 known plant viruses that can cause serious damage to the plants they infect. Globally, plant viruses can cause a complete crop failure even with updated pest and disease management measures. In this chapter the main virus diseases of pulses, cereals and canola, their symptoms, disease cycles and management are discussed.

Viruses cause a variety of symptoms in plants they infect and can be present in plants without showing any symptoms. Common virus symptoms are local lesions, mosaic patterns, yellowing, leaf rolling or curling, ringspots, necrosis and total plant death. Some viruses are seed-borne, others are mechanically transmitted however, most viruses are transmitted by insect vectors.

DISEASE CYCLE OF VIRUSES

Non-persistent Viruses

The primary source of infection of non-persistent viruses is infected seed. If the seed infection level is one per cent, one plant in every 100 will be virus-infected, therefore it will be randomly distributed across the field. The secondary infection happens by aphids. Aphids acquire the virus from primary infected plants or weeds and spread them to healthy crops within a short time span from a few minutes to a few hours. Aphids lose infectivity after a few probes because these types of viruses are not kept long on aphid's mouth parts and aphids do not remain infective throughout their life.

These viruses do not go through a lifecycle like many other pathogens. They cannot survive for very long outside the plant and they rely solely on aphids to spread them between live plants. These viruses can survive for long periods of time in seed, but do not have stages which allow them to survive in the soil or stubble as sources of infection for future crops.

Persistent Viruses

Persistent viruses are phloem restricted and only transmitted by aphids. Aphids need to feed on plants for hours to days to transmit the virus. The aphids remain infected for their whole life. These viruses are not seed-borne. The source of these viruses lie in over-summering perennial weeds.

In western Victoria, the most common non-persistent (and/or semi-persistent) viruses are *Alfalfa mosaic virus* (AMV), *Bean yellow mosaic virus* (BYMV), *Cucumber mosaic virus* (CMV) and *Pea seedborne mosaic virus* (PSbMV) in pulses, *Wheat streak mosaic virus* (WSMV) in cereals and *Turnip mosaic virus* (TuMV) and *Cauliflower mosaic virus* (CaMV) in canola. The main persistent (phloem limited) viruses are *Turnip yellows virus* (TuYV), *Bean leafroll virus* (BLRV) and *Subterranean clover stunt virus* (SCSV) in pulses, yellow dwarf viruses (YDV) in cereals and *Turnip yellows virus* in canola.

PULSE VIRUSES

The pulse viruses commonly found in Australia are *Alfalfa mosaic virus*, *Bean yellow mosaic virus, Cucumber mosaic virus, Pea seed-borne mosaic virus, Bean leafroll virus, Turnip yellows virus, Soybean dwarf virus* and *Subterranean clover stunt virus*. These viruses are listed in Tables 15.1 & 15.2.

AMV, BYMV, CMV and PSbMV are seed-borne, mechanically transmissible or transmitted by aphids in a non-persistent way (aphid feeds on a plant for a few minutes to hours, then the virus is lost from the mouth parts). BLRV, TuYV, SbDV and SCSV are phloem-limited and only transmitted by aphids in a persistent way (the virus stays in the aphid vector for life).

A number of factors interact to determine whether or not a particular year is conducive to virus spread. The main factors which influence virus spread are those that affect the aphid population (such as the weather) and the availability of sources of virus for the aphids to spread (seed, weeds, pasture hosts, etc.).

What to Look For

A number of factors may affect the development of symptoms in the field including the cultivar, infection (seed-borne or during growing season) and other stresses. In some situations, there may be no apparent symptoms on infected plants whereas in other situations, stress symptoms in healthy plants may be mistaken for virus symptoms.

The common aphid vectors of pulse viruses in western Victoria are the green peach aphid (*Myzus persicae*) (Figure 15.1), blue green lucern aphid (*Acyrthosiphon kondoi*), spotted alfalfa aphid (*Therioaphis trifolii forma maculate*), potato aphid (*Macrosiphum euphorbiae*) and leaf-curling plum aphid (*Brachycaudus helichrysi*).

Table 15.1. Seed-borne pulse viruses and their pulse hosts

VIRUS CROP	AMV	BYMV	CMV	PSBMV
Chick pea	X	X	X	X
Faba bean	*	X	X	X
Field pea	X	X	X	X
Lentil	X	X	X	X
Vetch	X	X	X	X
Narbon bean	*	*	X	X
Lathyrus	X	*	*	X
Lupins- L. angustifolius	X	*	X	

X= seed-borne
** plants may be infected but virus is not seed-borne*

Table 15.2. Common persistent viruses of temperate pulses

VIRUS CROP	BLRV	TUYV	SCSV
Chick pea	*	*	*
Faba bean	*	*	*
Field pea	*	*	*
Lentil	*	*	*
Vetch	*		
Narbon bean	*	*	*
Lathyrus	*		*
Lupins- L. angustifolius	*	*	

X= seed-borne
** plants may be infected but virus is not seed-borne*

*Figure 15.1. Green peach aphid (*Myzus persicae*); a common vector of pulse and canola viruses*

CHICKPEA VIRUSES

What to Look For

Alfalfa mosaic virus (AMV): Desi chickpeas show shoot tip necrosis combined with chlorosis and reddening of the leaf margin. Kabuli chickpeas show yellowing and necrosis of tips and stunting of plants.

Cucumber mosaic virus (CMV): Desi chickpeas show chlorosis, reddening and stunting of plants and Kabuli chickpeas show chlorosis and yellowing of leaves and stunting of plants (Figure 15.2).

Bean yellow mosaic virus (BYMV): Desi chickpeas show apical necrosis and reddening, plant stunting and premature senescence. Kabuli chickpeas show apical necrosis and chlorosis and plant stunting and premature senescence.

Pea seed-borne mosaic virus (PSbMV): Chlorosis on new shoots, mottling of leaves, down curling of leaves and plant stunting.

Turnip yellows virus (TuYV): Chlorosis and yellowing of whole plant and stunting in Kabuli chickpea (Figure 15.3) and purple leaves in Desi chickpea (Figure 15.4). Early infected plants often die.

Figure 15.2. Yellow tip symptoms of CMV in kabuli chickpea

Figure 15.3. TuYV symptoms in kabuli chickpea

Figure 15.4. TuYV symptoms in desi chickpea

FIELD PEA VIRUSES

What to Look For

Alfalfa mosaic virus (AMV): Chlorosis in new shoots, necrotic spots on leaves and streaking, necrosis of new or old leaves.

Cucumber mosaic virus (CMV): Chlorosis and yellow tips (Figure 15.5).

Bean yellow mosaic virus (BYMV): In some cases the virus may be symptomless or there can be mosaic symptoms, leaf deformation, severe stunting of the plant and premature senescence.

Pea seed-borne mosaic virus (PSbMV): In some cases the virus may show no symptoms or there may be downward curling of leaves and mild to severe plant stunting. The infected plants may produce seeds having brown marks or ringspots (Figure 15.6).

Turnip yellows virus (TuYV): Stunting and yellowing of plants (Figure 15.7).

Figure 15.5. CMV infected pea plant on the right and healthy plant on left

Figure 15.6. Symptoms of PSbMV on pea seeds

Figure 15.7. TuYV infected pea plant on right and healthy plant on the left

FABA BEAN VIRUSES

What to Look For

Alfalfa mosaic virus (AMV): Chlorosis in new shoots, leaf rolling, red ringspots on leaves and plant stunting.

Cucumber mosaic virus (CMV): Symptoms are variable and range from no symptoms to systemic necrosis to plant death.

Bean yellow mosaic virus (BYMV): Mosaic, dark green islands, vein banding (Figure 15.8).

Pea seed-borne mosaic virus (PSbMV): Mosaic, vein banding, dark green islands.

Bean leafroll virus (BLRV): Rolling of leaves inwards with thick and leathery leaves and stunting of the plant (Figure 15.9).

Subterranean clover stunt virus (SCSV): Infected bean plants remain very stunted and yellowish (Figure 15.10).

Figure 15.8. Mosaic symptoms of BYMV in faba bean

Figure 15.9. Yellowing, leaf rolling and stunting symptoms of BLRV in faba bean

Figure 15.10. Stunting and yellow symptoms of SCSV in faba bean

LENTIL VIRUSES

What to Look For

Alfalfa mosaic virus (AMV): Necrosis on tip growth, twisting and deformation of leaves.

Cucumber mosaic virus (CMV): Chlorosis, yellowing and stunting of plants (Figure 15.11).

Bean yellow mosaic virus (BYMV): Chlorosis, leaf malformation and stunting of plants.

Pea Seed-borne mosaic virus (PSbMV): No symptoms or there may be chlorosis in new shoots, mottling on leaves, shoot tip necrosis and stunting of plants.

Turnip yellows virus (TuYV): stunting and yellowing of plants (Figure 15.12).

Figure 15.11. Yellowing and stunting symptoms of CMV in lentil plant (front) surrounded by healthy plants

Figure 15.12. Stunting and yellowing symptoms of TuYV in lentil (centre)

LUPIN VIRUSES

What to Look For

Alfalfa mosaic virus (AMV): The symptoms are tip necrosis, yellow leaves and mild stunting.

Cucumber mosaic virus (CMV): Reduced internodes, bunchy appearance and plant stunting. If the virus is carried in the seed the entire plant will be stunted and may die before maturity. A plant infected late in the season may have normal sized leaves at the bottom but those near the top, above the point of infection, will be less than half the normal size. The leaves on infected plants become bunched, curled down and chlorotic (pale in colour), particularly at the growing shoots. Infected plants may occur randomly throughout the paddocks. Often they will be in small patches, 1-2 metres in diameter (Figure 15.13).

Bean yellow mosaic virus (BYMV): The initial symptoms are yellowing of leaves followed by necrosis of growth tips and death of plant (Figure 15.14). The late infection may cause black pod symptoms. BYMV is a serious disease in narrow leafed lupins. Two strains of the virus occur in Western Australia. These are differentiated by symptoms in narrow-leafed lupin: the common necrotic (BYMV-N) strain kills the infected plant, and the less abundant non-necrotic (BYMV-NN) strain causes stunting without killing the plant. All BYMV strains which are endemic in Australia are not seedborne in lupins, unlike overseas strains.

Figure 15.13. Stunting and bunching symptoms of CMV in narrow-leaf lupins (front plants) surrounded by healthy plants

Figure 15.14. Symptoms of BYMV in narrow leaf lupin. The initial symptoms are yellowing of leaves, followed by necrosis of growth tips and death of plants

MANAGEMENT OF PULSE VIRUSES

- Growing virus resistant varieties is the long term best option, but the number of resistant varieties is limited. Breeding is underway to develop a faba bean with BLRV resistance and field pea with PSbMV and BLRV resistance.
- Sowing virus tested seed which has a virus level less than 0.1-0.5 per cent is an effective way to control seed-borne viruses which can only be spread short distances in the field by their aphid vectors (non-persistent transmission).
- Eliminating weeds and self-sown pulses. These are a source of virus and aphids and this is usually where they survive between crop growing seasons.
- Monitoring aphids, particularly at the early growth stages of the crop. If aphids develop heavy colonies at this early stage, then it may be economical to spray the crop with an aphicide.
- Good plant stands with minimal bare ground will reduce aphid colonisation.
- Rotation of pulses with cereals and reduce self-sown hosts and weeds.
- Removal of plants with symptoms will reduce the amount of infected seed harvested (appropriate for some seed crops). The amount of virus infection in the harvested seed (per cent) depends not only on the number of infected plants, but also on the rate of seed transmission of the virus.
- Seed treatment with neonicotinoid (e.g. imidaclopridi) insecticide reduces aphid feeding and virus spread. It is especially beneficial for persistently transmitted viruses.

CEREAL VIRUSES

Cereal crops are infected by a number of viruses but yellow dwarf viruses (such as *Barley yellow dwarf viru*s (BYDV) and *Cereal yellow dwarf virus* (CYDV) and *Wheat streak mosaic virus* (WSMV) are the most common in western Victoria.

*Figure 15.15. Bird cherry-oat aphid (*Rhopalosiphum padi*); a common vector of yellow dwarf viruses*

YELLOW DWARF VIRUSES (YDVS)

Yellow dwarf viruses are a group of closely related virus species belonging to the family *Luteoviridae*. Yellow dwarf disease is the most widely distributed and most destructive virus disease of cereals. Yield loss is greatest from infection early in the growing season which can be up to 80 per cent in severe cases where a susceptible variety has become infected soon after sowing. YDVs are only transmitted from infected to healthy plants by aphid vectors. They are transmitted by a number of aphids but the oat aphid (*Rhopalosiphum padi*) (Figure 15.15) and the corn aphid (*Rhopalosiphum maidis*) are the most common YDV vectors in western Victoria and across Australia.

Over 150 plant species within the Poacae family are characterised as hosts of YDVs, including food crops such as wheat, barley, oat and corn. YDV infection has a negative effect on plant growth as it decreases root biomass, diminishes plant vigour and greatly reduces grain yield and quality.

The most common symptoms of YDV infection are plant stunting and leaf discoloration (depending on the crop; either yellow or red) which starts from the tip of the leaf and spreads towards the base (Figure 15.16). The severity of this disease largely depends on the inoculation time; plants are at their most vulnerable when they are infected in the early growth stage. In addition, abiotic factors, including drought and heat, can intensify severity of this disease.

Hosts

YDVs can persist in most small grain cereals (wheat, barley oats), corn and many perennial and annual grasses. The four most important grass species acting as reservoirs for BYDV are kikuyu, paspalum, couch grasses and African lovegrass.

Disease Cycle

The disease occurs on most cereals and numerous grasses but is not known to affect dicotyledonous plants. Infection in the plant is restricted to the conducting tissue (phloem).

YDVs are not transmissible through seed, soil, sap or by insects other than aphids. Aphids migrate into cereal crops in autumn and spring. The extent of any autumn migration is important as early infection of YDV in crops can affect crop yields severely. Aphids need to feed on an infected plant for at least 5 minutes followed by a latent period of 12 hours before the virus will transmit to a healthy plant. Aphids remain infected for the rest of their life. Ten species of YDV have been identified, but in Australia the species BYDV-PAV is the most common.

What to Look For

Symptoms of YDV infection can be confused with those caused by nutrient deficiencies, waterlogging or other plant stresses that cause yellowing and striping of leaves.

Besides changing colour, infected plants are stunted or dwarfed. In severe infections, heads may fail to emerge or fewer tillers may develop and sterility is not uncommon. Leaf symptoms differ between wheat, barley and oats.

Figure 15.16. Symptoms of YDV infection in wheat (A and B) and barley (C)

Figure 15.17. YDV symptoms in wheat

Wheat

Infected wheat plants develop a slight to severe yellowing or pale striping between veins (interveinal chlorosis) in young leaves (Figure 15.17). Leaf tips can also die. If a sensitive variety is infected before tillering the plant is usually stunted, has fewer tillers and more sterile ones. Grain matures early, yield is greatly reduced and grain is shrivelled. Effects are milder with a late infection.

Figure 15.18. Yellow leaf symptoms of YDV infection in barley

Barley

In barley, YDV infection causes a characteristic bright yellowing of the leaves (particularly older leaves) and pale yellow stripes between the leaf veins plus chlorotic blotching of young leaves, (Figure 15.18). Early infected barley plants are stunted and produce low grain yields and shrivelled grain. Tillering can be stimulated by infection, but most tillers then develop poorly and produce sterile heads. Plants infected after tillering have milder symptoms and yields are less severely affected.

Figure 15.19. Red leaf symptoms of YDV infection in oat

Oats

In oats, the symptoms of YDV infection are very striking. Most varieties develop reddening (crimson, pink or purple colour) of the young leaves from the tips down, which sometimes begins as blotching especially on older leaves (Figure 15.19). Stunting, an increase in sterile tillers or abortion of florets result in low grain yields and shrivelled grain. As in wheat and barley, the effect of YDV infection is greatest in early-infected plants.

Figure 15.20. YDV symptoms in rye grass

Grasses

There are no obvious symptoms of YDV infection in many grasses (e.g. kikuyu grass). However, some grasses (e.g. annual and perennial ryegrasses) may develop reddening or purpling of leaf tips while others (e.g. phalaris) may develop yellowing of older leaves (Figure 15.20).

WHEAT STREAK MOSAIC VIRUS (WSMV)

WSMV is transmitted through infected seed, mechanically and by the wheat curl mite (*Aceria tosichella*). The wheat curl mite is invisible to the naked eye. This virus has been found in all wheat growing regions of Australia.

What to Look For

Symptoms on leaves could be seen as light green streaks parallel to the veins. The streaks develop into blotches and form a pattern of yellow and green mosaic (Figure 15.21). Infection at an early stage can cause heads developing no seed or shrivelled grain and stunting. Mite symptoms in plants could coincide with virus symptoms, showing rolling of leaves from margins to inwards (Figure 15.22).

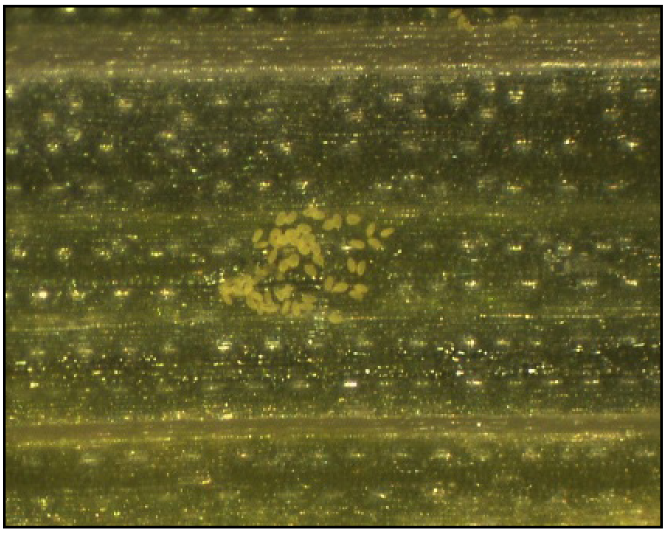

Figure 15.21. Wheat curl mites feeding on wheat leaf (mites found by uncurling affected leaves).

*Figure 15.22. Wheat curl mite (*Aceria tritici*)*

Figure 15.23. Yellow and green streak symptoms

Figure 15.24. Wheat curl mite feeding symptoms

CANOLA VIRUSES

Three viruses are reported in Australian canola crops: *Turnip yellows virus* (TuYV) , *Turnip mosaic virus* (TuMV) and *Cauliflower mosaic virus* (CaMV) but TuYV is considered the most economically important in winter canola.

Infection with TuYV is common and all canola varieties and hybrids are susceptible. TuMV and CaMV tend to occur at low incidences mostly in south western Victoria, especially in dual-purpose spring-sown canola. TuYV has been shown to reduce canola yield by up to 46 per cent and reduced oil quality. Overseas studies indicate TuMV and CaMV can also cause significant yield losses.

Symptoms

Infection with TuYV causes plant stunting and purpling or reddening of lower leaves, CaMV causes stunting and yellow vein clearing, while TuMV causes stunting and mosaic which is sometimes associated with line patterns.

These viruses are not seed-borne and are transmitted by the green peach aphid (*Myzus persicae*), cabbage aphid (*Brevicoryne brassicae*) and turnip aphid (B*revicoryne pseudobrassicae*). They survive in weeds or volunteer canola host plants outside the growing season and are then spread from these infected plants into crops by aphids which act as vectors for virus transmission. TuYV is transmitted persistently while CaMV and TuMV are non-persistent viruses.

TURNIP YELLOWS VIRUS (TUYV)

This is the most important virus of oilseed rape and canola crops in Australia. TuYV is wide spread throughout Australia and in 2014 emerged as an epidemic of canola crops in South Australia, destroying thousands of hectares. The incidence of this virus is high in Victoria. This virus is transmitted by several aphid species but the green peach aphid is the most efficient vector. To date, no resistant varieties are available.

What to Look For

Infected canola crops show a variety of symptoms but also can be symptomless. Symptoms include reddening of leaf margins and interveinal chlorosis (Figure 15.25). Infected plants may be dwarfed, leaves may be thicker, leathery, yellow and brittle. Early infected plants may die as a result of TuYV infection.

Disease Cycle

The virus and aphid vectors persists over summer in fodder turnips and in weed species, then aphids transfer virus into canola crops in the winter. TuYV is not seed-borne. Annual sampling of green peach aphid populations have shown that up to 72 per cent of winged aphids carry TuYV. The virus is phloem limited; aphids need to ingest infected sap to acquire the virus.

Figure 15.25. BWYV symptoms in canola.

TURNIP MOSAIC VIRUS (TUMV)

This virus belongs to the potyvirus group and was first reported in the USA. It is distributed worldwide and transmitted non-persistently by aphids, but is not seed-borne. It has been found in south western Victoria. The incidence and severity of TuMV in canola crops is not as great as TuYV.

What to Look For

In turnips, TuMV shows pale chlorotic or necrotic local lesions, systemic vein clearing and veinal flecking developing into severe mosaic and stunting of the plant. Similar symptoms are observed in canola (Figure 15.26).

Disease Cycle

The virus is transmitted non-persistently by aphids and through sap inoculations. It is not seed-borne. The virus over-summers in weed species or in rape mustard sown for fodder in summer. In winter canola crops it is found in low incidence.

Figure 15.26. TuMV symptoms in canola

CAULIFLOWER MOSAIC VIRUS (CAMV)

This is a DNA virus with a restricted host range but is distributed worldwide in temperate regions. It is transmitted by many aphid species in a non-persistent manner. This virus is found south west of Victoria in low incidence.

What To Look For

Symptoms of CaMV include vein clearing, leaf distortion and bunchy appearance of the infected plant (Figure 15.27).

Disease Cycle

The virus is transmitted mechanically and by aphids. It is not transmitted through seeds.

Virus Management

To date, virus resistant varieties of canola are not available so integrated management practices are advised. These include weed control, removal of green bridge during summer, sowing into standing stubbles, the use of neonicotinoid insecticide seed dressings and in-crop aphid control based on monitoring

Figure 15.27. Syptoms of CaMV in canola

FURTHER INFORMATION

More detailed information can be obtained from:

Victorian Cereal Disease Guide

agriculture.vic.gov.au/cereal-disease-guide

Victorian Pulse Disease Guide

agriculture.vic.gov.au//pulse-disease-guide

Victorian Crop Sowing Guide

agriculture.vic.gov.au/crops-and-horticulture/grains-pulses-and-cereals/crop-production/general-agronomy/victorian-crop-sowing-guide

Canola Ratings

grdc.com.au/GRDC-FS-BlacklegManagementGuide

Other variety guides (e.g. Western Australia)

grdc.com.au/resources-and-publications/all-publications/nvt-crop-sowing-guides

Pulse Seed Treatments and Foliar Fungicides

www.pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf Pulse Australia

www.pulseaus.com.au

AsureQuality
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FUNGICIDES

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INTRODUCTION

Fungicides are an important part of disease control in modern farming systems and an integral part of many integrated disease management strategies. In field crops fungicides can be applied to the seed, fertiliser, soil, or foliage.

Fungicides control disease in one or a combination of ways: from inhibiting spore germination, hyphal growth, or limiting development of spores. Fungicides may be fungistatic, meaning they prevent new growth or sporulation, or fungicidal, meaning they kill the fungus outright.

Based on the way they move in the plant we can distinguish between contact and systemic fungicides (Table 16. 1). Contact fungicides do not move from the point where the spray is deposited on the plant and act as a surface barrier that prevents spore germination mainly. However, contact fungicides will not be effective at controlling an existing infection. Systemic fungicides act on the surface but are also absorbed into the plant tissue and transported upwards by the xylem of the plant. Systemic fungicides can be used for the control of latent infections (have curative activity) and symptomatic disease (eradicant activity).

Any fungicide used in Australia must be registered with the Australian Pesticides and Veterinary Medicines Authority (APVMA). By using only registered agricultural chemicals the user, industry and public can be assured that, if the chemical is used in accordance with the label, the risks posed by that use in terms of public health, trade and the environment are minimised.

SEED, FERTILISER AND FOLIAR APPLICATIONS OF FUNGICIDES

Fungicides can be applied to a crop in different ways (e.g. to seed, soil, fertiliser or foliage) and at different times during the season. When and how a fungicide is applied to a crop will depend on many factors including the target disease, cost, seasonal conditions, host resistance and on-farm logistical considerations.

Seed Treatments

There are a large range of disease control options provided by fungicidal seed treatments. For example, in cereals the most basic treatments provide control of bunts and smuts only, while there are others that also provide many weeks of suppression of a range of foliar and/or root diseases. Seed treatments protect the seed either by controlling fungi present on the seed surface or carried internally in the seed, or by preventing infection from fungi present in the soil or on crop residue in the soil. Some treatments will protect a young seedling against early leaf disease or root rot infection, but in most cases, seed treatments are no longer effective after seedling emergence. A seed treatment can also reduce the potential for introducing a pathogen into an area where it is not established.

In general, seed treatments have either systemic or contact activity. A systemic product is required to control fungi carried within the seed's embryo, cotyledons, or seed coat, (i.e., smut in barley, ascochyta in lentil). A systemic seed product is also needed to control early seedling diseases such as scald in barley, stripe rust in wheat, or early season infection of ascochyta in lentil. A contact or protectant product is adequate for surface-borne or soil-borne fungi.

Fertiliser/In Furrow Treatments

The application of fungicides to fertiliser has become common practice in Australian grain production, with some recent adoption of the liquid banding of fungicides at planting. Fungicides applied in this way can reduce the severity of the root disease Take-all and give long term control of stripe rust. Some newer chemistry applied either to fertiliser or in furrow via liquid banding application have been shown to reduce the severity of Rhizoctonia in cereals.

The application of systemic fungicides to fertiliser may reduce the need for a foliar fungicide application later in the season for stripe rust control, thus reducing the in-season disease control requirements at a busy time of the year. However, this prevents the ability to monitor seasonal conditions and disease development and avoid the fungicide cost if the season is not conducive for disease.

It is important to remember that fertiliser-applied fungicides do not control bunts and smuts, so seed applied fungicides are still required.

Foliar Fungicides

Foliar fungicides are an important tool to protect the above ground plant from fungal diseases. Foliar fungicides provide growers with the ability to monitor seasonal conditions and disease development to only apply when necessary and then also match the active and rate to the actual disease present. Through scouting of crops for disease, in many cases un-necessary fungicide applications can be avoided.

It is important to note that foliar fungicides are most effective if applied in a preventative manner, either at the first sign of disease or before disease is present in the crop but present in the district and conducive weather conditions are forecast.

Estimating the potential economic impact of diseases can often be difficult when determining if in-crop fungicide applications are warranted. To support these difficult decisions the GRDC have supported the development of apps to assist with the management of several diseases (see chapter 17 - Technology). These Apps are available for free download for tablets via the Apple and Google Play stores.

MODE OF ACTION

Fungicides prevent fungal growth by interfering with critical cellular processes within the fungus and how a fungicide affects a fungus is called its mode of action. Fungicides are divided into activity groups based on their mode of action (Table 16.2) with types of fungicide activity explained further in Table 16.1.

Most fungicides used in field crops in Australia are within five chemical groups (groups 1, 2, 3, 7 and 11) and are described as follows:

Group 1 - Benzimidazoles

These products provide protective and curative control and show translaminar mobility. Mode of action is by inhibiting mitosis, more specifically, by binding the tubulin needed for cell and nuclear division thus resulting in death of the fungus. Examples include the active ingredients carbendazim and thiabendazole, which are used as pulse fungicides.

Group 2 - Dicarboximides

Many of the pulse fungicides fall within this group (e.g. active ingredients iprodione and procymidone). Dicarboximides are systemic fungicides with both preventive and curative activity. These fungicides act on the fungi by inhibiting spore germination and affecting cell division. The benefits of these products are that they control a unique group of fungi including botrytis and sclerotinia.

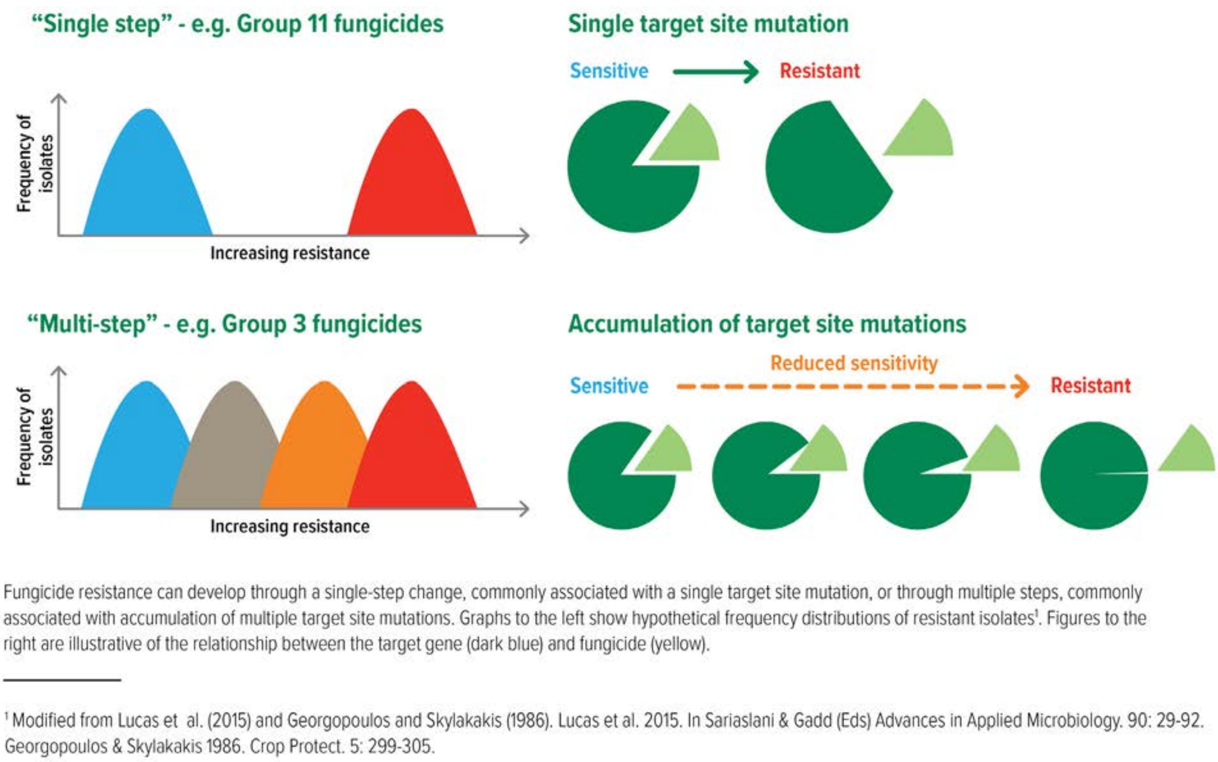


Figure 16.1. How disruptive or single-step (top) and multi-step (bottom) fungicide resistance develops. Source: Fungicide resistance management in Australian grain crops. Grains Research and Development Corporation, Australia.

Group 3 - Demethylation inhibitors (DMI) – Triazoles

Triazoles are de-methylation inhibitors (DMI) which prevent ergosterol biosynthesis. This group is widely used in Australian field crops. Triazoles have systemic activity and provide protective, curative and eradicant control. Examples include the active ingredients propiconazole, tebuconazole, triadimenol, triadimefon, triticonazole, and epoxyconazole.

Group 7 - Succinate Dehydrogenase Inhibitors (SDHI)

SDHIs are locally systemic, movement is translaminar and upward. SDHIs inhibit cellular energy production. Examples include carboxin, penflufen, fluxapyroxad or seed treatments combining difenoconazole (Group 3), metalaxyl-m (Group 4) and sedaxane (Group 7). Foliar fungicide formulations are also available on the Australian market e.g. bixafen and adepidyn.

Group 11 - Quinone Outside Inhibitor (QoI) - Strobilurins

QoIs contain the strobilurins which are preventative and locally systemic (translaminar). QoIs inhibit cellular energy production. Some QoIs, like azoxystrobin can move in the xylem. They are generally mixed with triazoles for agricultural use in Australia to reduce the chance of resistance developing.

FUNGICIDE RESISTANCE

Fungicide resistance is an increasingly important issue for Australian agriculture. Resistance of fungal pathogens to fungicides usually becomes a problem following the intensive use of fungicides for disease control. Continued use of a the same fungicide or fungicide chemical group can result in the selection of specific mutations and a build-up of resistance within the fungal population even to the point where that particular active or actives from the same group are no longer effective. The risk of fungicide resistance developing varies between the different fungicide groups and different fungal pathogens.

Types of resistance

There are two types of resistance to fungicides.

Multi-step (or continuous or quantitative) resistance is when the pathogen becomes less sensitive to the fungicide over time and gradually higher and higher rates of the active are required to maintain adequate control. In the field this is observed as a gradual decrease in sensitivity to the fungicide with growers having to apply higher and higher rates of fungicide to achieve adequate control. This gradual erosion of the fungicide efficacy is normally due to the accumulation of target site mutations and/or the overexpression of the target. This is currently the case with Septoria resistance to tebuconazole in south eastern Australia.

Disruptive (or discrete or qualitative) resistance is when the pathogen can suddenly tolerate high doses of fungicide and the rates required for adequate control are often impracticable. This is similar to an on/off switch. A fungicide will go from being effective at field rates to ineffective in one shift instead of gradually. This type of resistance is due to the development of target site mutations that have catastrophic effects on the binding of the fungicide to its target. This is the case with wheat powdery mildew resistance to Group 11 (strobilurin) fungicides.

Managing Fungicide Resistance

There are a range of strategies that can be used to prevent or delay the development of resistance in fungal populations. These include:

- Implement effective and integrated disease management strategies to control diseases. Reducing or avoiding the need to use fungicides through a range of strategies (i.e. crop rotation, resistant varieties, etc.) will extend their life by maintain low pathogen populations and the number of applications which reduces selection pressure on the pathogen population.
- Rotate your fungicides. Avoid the repeated application of the same active or the same group within the one season. Where possible use actives from different groups or if the same activity group must be applied use a different active within that group. This applies to seed dressing, in furrow and foliar formulations.
- Use fungicides that contain mixtures of more than one active ingredient.
- If resistance is present, or suspected, avoid or minimise use of that mode of action - this will only further select for resistance.
- Do not exceed label rates. Use a rate that provides effective disease control.

REGISTRATION OF FUNGICIDES

Agro-chemicals are constantly being reviewed for safety and efficacy. As new reduced-risk products become available older products may be deregistered. The federal body involved in the registration and review of pesticides is the Australian

Pesticides & Veterinary Medicine Authority (www.apvma.gov.au). The process of registering a product is thorough and requires information on environmental toxicity, safety to users, safety to consumers, fate of chemical breakdown and efficacy.

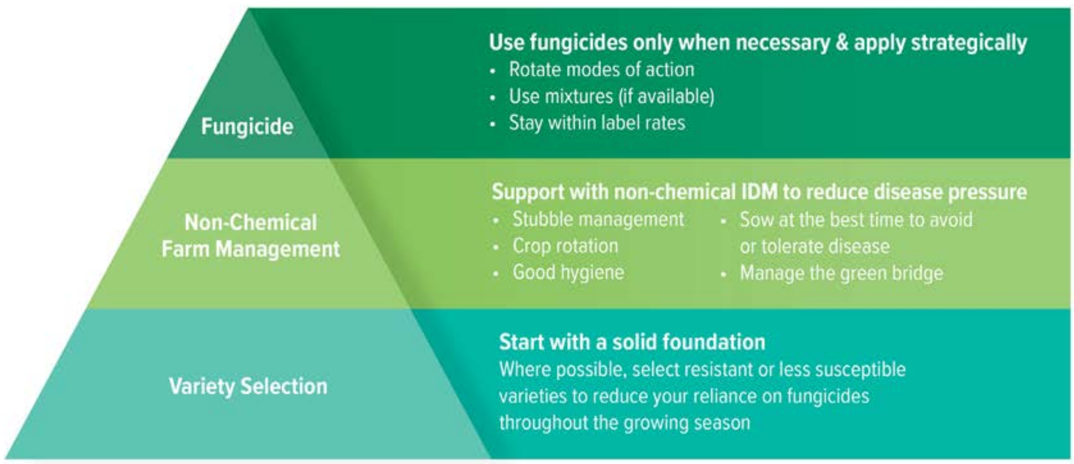
LICENCING AND USE OF CHEMICALS

Under the *Agricultural and Veterinary Chemicals (Control of Use) Act 1992* any person that uses restricted use chemicals such as S7 Dangerous Poisons must hold appropriate authorisation, such as an Agricultural Chemical Users Permit issued by the Department of Jobs, Precincts and Regions. This applies to some commonly used fungicides such as carbendazim and procymidone.

All restricted use chemicals must be used in strict accordance with the label, and the user must keep the required records of use of the chemicals.

It is illegal to use unregistered chemicals, and it is also illegal for a grower to sell agricultural produce that contains unacceptable chemical residues.

Off label use of restricted use chemicals in Victoria is not permitted for restricted use chemicals unless a permit has been obtained from the Australian Pesticides and Veterinary Medicines Authority (APVMA).



Fungicide resistance management. Growers should seek to provide a strong and reliable foundation of resistant or less susceptible crop varieties, supported by non-chemical integrated disease management that can be complemented by strategic and responsible use of fungicides.

Figure 16.2. General fungicide resistance management guidelines. Source: Fungicide resistance management in Australian grain crops. Grains Research and Development Corporation, Australia.

Table 16.1. Definitions for terms to describe fungicide activity and mobility

TYPES OF FUNGICIDE ACTIVITY/ MOBILITY	DESCRIPTION
Protective / Preventative Activity	Inhibits spore germination or kills germinating spores on the plant surface. Protectant fungicides must be applied to the plant prior to the arrival of the pathogen, or at least before it has a chance to germinate and enter its host. Coverage is very important because the fungicide must be in contact with the spore to be effective; hence new tissues from actively growing plants will not be protected. The majority of fungicides used in field crops in Victoria are in this category, (refer to Table 12.1 for examples).
Curative Activity	Inhibits fungal growth prior to symptoms appearing but can be effective on fungi once they've infected the host. Curative activity is limited to the early part of the incubation period, likely only for the first 24 to 36 hours after spore germination and infection. Curative products do not repair tissue that has already been damaged or killed by the fungus. Many fungicides fall within this category, (see Table 12.1 for examples).
Eradicant Activity	These fungicides have the ability to limit growth and spore production even after symptoms are visible. Some fungicides fall within this category. Examples include those active ingredients in the triazole family, e.g. propiconazole, tebuconazole, and triadimefon.
Systemic	Systemic fungicides are able to penetrate the plant. They show mobility via phloem.
Contact (non-systemic)	These fungicides do not penetrate the plant. Typically they are not redistributed and their action is restricted to the treated foliage.
Translaminar	Describe the movement of the fungicide from the sprayed to the unsprayed surface.

Table 16.2. Fungicide chemical groups for resistance management and related information (adapted from CropLife www.croplife.org.au)

Activity Group Code (FRAC Code)	FUNGICIDE MODE OF ACTION GROUP	CHEMICAL FAMILY	ACTIVE INGREDIENT	TYPE OF ACTIVITY	MODE OF ACTION	RISK FOR RESISTANCE
1	Methyl Benzimidazole Carbamates (MBC)	Benzimidazoles	Carbendazim Thiabendazole	Systemic with apoplastic mobility (protectant, curative)	Systemic with apoplastic mobility (protectant, curative)	High
		Thiophanates	Thiophanate-methyl			
2	Dicarboximides	Dicarboximides	Iprodione Procymidone	Systemic with apoplastic mobility (protective, curative)	Inhibition of lipids and membrane synthesis	Medium to High
3	Demethylation Inhibitors (DMI)	Triazoles1	Cyproconazole Difenoconazole Epoxiconazole Fluquinconazole Flutriafol Ipconazole Propiconazole Prothioconazole Tebuconazole Triadimefon Triadimenol Triticonazole	Systemic with apoplastic mobility (protectant, curative, eradicant)	Inhibition of sterol biosynthesis in membranes	Medium
4	Phenyl Amides (PA)	Acylalanines1	Metalaxyl Metalaxyl-M	Systemic (protectant, curative)	Affect RNA synthesis	High
7	SDHI (Succinate dehydrogenase inhibitors)	Oxathiin carboxamide	Carboxin Oxycarboxin	Systemic (apoplastic mobility)	Inhibits mitochondrial respiration (SDHIs)	Medium
		Pyridine carboxamide	Boscalid			
		Pyrazole carboxamide	Sedexane Penflufen Fluxapyroxad Bixafen			
11	Quinone Outside Inhibitors (QoI) (Strobilurins)	Methoxy acrylate	Azoxystrobin Famoxadone	Systemic activity with apoplastic + acropetal mobility (protectant, curative)	Inhibition of mitochondrial respiration	High
		Oximino acetate	Kresoxim-methyl Trifloxystrobin			
		Methoxy carbamate	Pyroclostrobin			
12	Phenylpyrroles (PP)	Phenylpyrroles	Fludioxonil		Affect proteins involved in membrane permeability	Low to Medium
17	Hydroxyanilide	Hydroxyanilide	Fenhexamid^		Inhibition of tubulin formation during mitosis	High

Table 16.2. cont. Fungicide chemical groups for resistance management and related information (adapted from CropLife www.croplife.org.au)

Activity Group Code (FRAC Code)	FUNGICIDE MODE OF ACTION GROUP	CHEMICAL FAMILY	ACTIVE INGREDIENT	TYPE OF ACTIVITY	MODE OF ACTION	RISK FOR RESISTANCE
M1	Multi-site activity	Inorganic	Copper cuprous oxide Copper hydroxide Copper oxychloride Copper ammonium acetate Tribasic copper sulphate Copper octanoate	Contact (protectant)	Act as multi inhibitors with several sites of action (sites may differ between group members)	Low
M2	Multi-site activity	Inorganic	Sulphur Potassium bicarbonate Calcium polysulfide	Contact (protectant)	Act as multi inhibitors with several sites of action (sites may differ between group members)	Low
M3	Multi-site activity	Dithiocarbamate	Mancozeb Metiram Thiram Propineb Zineb Ziram	Contact (protectant)	Act as multi inhibitors with several sites of action (sites may differ between group members)	Low
M4	Multi-site activity	Phthalimide	Captan*	Contact (protectant)	Act as multi inhibitors with several sites of action (sites may differ between group members)	Low
M5	Multi-site activity	Chloronitriles	Chlorothalonil	Contact (protectant)	Act as multi inhibitors with several sites of action (sites may differ between group members)	Low

1 Not a comprehensive list of actives. Only the most relevant actives listed here. For a full list visit www.croplife.org.au

* Permitted use only (PER81406)   ^ Permitted use only (PER14211)

FURTHER INFORMATION

More detailed information can be obtained from:

AFREN | Australian Fungicide Resistance Extension Network

afren.com.au

Fungicide Resistance Management In Australian Grain Crops

afren.com.au/resources/#management-guide

FRAC | Fungicide Resistance Action Committee

www.frac.info

The Fungicide resistance action committee website has a range of useful resources that provide and international perspective on fungicide resistance.

TECHNOLOGY AND SOCIAL MEDIA

Authors: Luise Fanning (Agriculture Victoria)

INTRODUCTION

There are a whole range of products, services, tools and technologies you can use to identify and determine how best to manage pests and diseases. What are they, what should you use each for and when? This chapter pulls together a shortlist of diagnostics services, online tools and subscriptions which will help you keep on top of what's the latest and need to know when it comes to providing the best services in relation to crop disease identification and management for your clients.

DIAGNOSTIC SERVICES

PREDICTA®B

What is it?

PREDICTA®B is a DNA-based soil testing service to assist grain producers to identify which soil-borne pathogens pose a significant risk to their crops prior to seeding so steps can be taken to minimise the risk of yield loss.

When should I use PREDICTA®B?

PREDICTA®B has multiple uses, including:

- Identifing which soil-borne pathogens pose a significant yield risk to crops prior to sowing
- Monitoring the effect of crop rotation on pathogen levels
- In crop disease testing for soil-borne pathogens.

Other uses include screening paddocks to determine which have the lowest risk for a particular disease (e.g. crown rot when sowing durum crops) to minimise yield loss each year.

Agronomists wishing to use the service will need to be accredited to ensure proper sampling protocol is followed, and results are accurately interpreted. Search 'PREDICTA®B' to find out more or visit pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

Crop Health Services

What is it?

Crop Health Services (CHS) is the commercial plant pest and disease diagnostics service operated by Agriculture Victoria. CHS offers a broad range of diagnostic tests.

When should I use Crop Health Services?

For species identification and commercial testing of samples, CHS can identify a very broad range of fungi, bacteria, viruses and nematodes. Search 'Crop Health Services' to find out more or visit agriculture.vic.gov.au/support-and-resources/services/diagnostic-services#h2-1

DDLS – Diagnostic Laboratory Services

What is DDLS?

DDLS - Plant pathology is a diagnostic service under the WA Department of Primary Industries and Regional Development, which delivers high quality and timely services predominantly in Western Australia, but also to clients Australia-wide.

When should I use DDLS?

For species identification and commercial testing of samples. DDLS are also able to test seed samples for virus'. Search 'DDLS Plant Pathology' for more information about services and pricing or visit www.agric.wa.gov.au/ddls-plant-pathology-0

CropSafe

CropSafe is an active, self-help 'eyes in the field' surveillance system looking out for new pests and diseases over the Victorian grains belt.

The program is used as an in-season aid with unusual symptom diagnosis. Agronomists can join the network for support with crop disease identification and add to Victoria's area of freedom data to help maintain market access. Search 'CropSafe' to find out more or visit agriculture.vic.gov.au/crops-and-horticulture/grains-pulses-and-cereals/cropsafe-program

ONLINE APPLICATIONS TO HELP MANAGE CROP DISEASES

Innovations in technology are providing new opportunities to access information including tools to help with crop disease management. There are a wide range of tools available to help the modern agronomist, all accessible from a tablet or smart phone. However, knowing what to use and how to achieve the maximum benefit can sometimes be difficult and more often a bit confusing.

To help you avoid information overload we have narrowed down the most useful apps, websites and social media channels that provide key disease management information for Victorian agronomists and growers. Each has some comments relating to the relevance and use of information, plus we have included some up and coming projects to keep an eye out for.

BlacklegCM - Blackleg Management App

BlacklegCM is an app for growers and agronomists available on iPads and Android tablets which enables comparison of blackleg management strategies to identify the best return on investment.

When should I use BlacklegCM?

As a management tool for blackleg in canola BlacklegCM allows users to compare multiple management strategies to see which is predicted to have a better net return. It can also be used to show the benefits of trying a new management strategy. This is a tool which can be used throughout the growing season as well as in planning. Its accuracy improves if you know what your yield potential is going to be at the end of the season. You can do your planning for anticipated management at the beginning of the year, then reassess at sowing based on preseason rainfall, and during the season to determine whether to apply in-season foliar fungicides.

What the developers say

"BlacklegCM is a tool designed to assist growers and consultants to determine the best and most profitable management strategy to reduce blackleg disease and increase profits, accounting for the major factors that influence blackleg severity. The user can specify factors relating to paddock selection, seasonal conditions, prices and management options so that the output relates to their cropping circumstance. Therefore, the user can explore their options for disease control and understand the relative importance of each factor."

Where can I download BlacklegCM?

Visit the app store on your tablet and search "BlacklegCM. Note: this app is only available on tablets to ensure full functionality.

SclerotiniaCM – Sclerotinia in Canola Management App

SclerotiniaCM is an app for growers and agronomists available on iPad and Android tablets to help make decisions around fungicide application and the impact they may have on sclerotinia.

When should I use SclerotiniaCM?

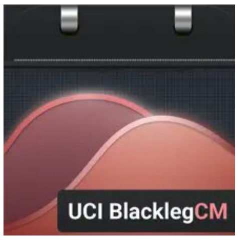
As a management tool SclerotiniaCM gives users the ability to see how likely a fungicide application is to provide a yield benefit.

What the developers say

"SclerotiniaCM uses a forecasting model to assist canola growers with fungicide application decisions, on a paddock by paddock basis, and the likely economic returns from those decisions. The user can specify individual paddock data as well as recent and expected weather conditions so that the output relates to their own cropping circumstances."

Where can I download SclerotiniaCM?

Visit the app store on your tablet and search "SclerotiniaCM. Note this app is only available on tablets to ensure full functionality.



UCI BlacklegCM – Canola Management App

UCI BlacklegCM helps you make decisions for the management of blackleg upper canopy infections (UCI) in canola crops in Australia.

When should I use UCI BlacklegCM?

As a management tool UCI BlacklegCM gives users the ability to see how likely a fungicide application is to provide a yield benefit.

Where can I download UCI BlacklegCM?

Visit the app store on your tablet or, android, or iPhone and search "UCI BlacklegCM".Or visit canola.shinyapps.io/UCI-blackleg/ from any computer browser.

StripeRustWM – Stripe Rust Management App

StripeRustWM is an app for growers and agronomists available on iPads and Android tablets which enables comparison of stripe rust management strategies to identify the best return on investment.

When should I use StripeRustWM?

As a management tool for stripe rust in wheat, StripeRustWM allows users to compare multiple management strategies to see which is predicted to have a better net return. It can also be used to show the benefits of trying a new management strategy. This is a tool which can be used throughout the growing season as well as in planning. Its accuracy improves with local rust epidemic information (e.g. was there a green bridge, are there hot spots in other paddocks).

You can do your planning for anticipated management at the beginning of the year, then reassess during the season to determine whether to apply in-season foliar fungicides.

What the developers say

"Stripe rust management app for wheat. StripeRustWM uses a forecasting model to assist wheat growers with fungicide application decisions, on a paddock by paddock basis, and the likely economic returns from those decisions. The user can specify individual paddock data as well as expected weather conditions so that the output relates to their own cropping circumstances."

Where can I download StripeRustWM?

Visit the app store on your tablet and search "StripeRustWM". Note this app is only available on tablets to ensure full functionality.

YellowSpotWM – Yellow Leaf Spot Management App

YellowSpotCM is an app for growers and agronomists available on iPads and Android tablets which enables comparison of yellow leaf spot management strategies to identify the best return on investment.

When should I use YellowSpotCM?

As a management tool for yellow leaf spot in wheat YellowSpotCM is allows users to compare multiple management strategies to see which is predicted to have a better net return. It can also be used to show the benefits of trying a new management strategy. This is a tool which can be used throughout the growing season as well as in planning. Its accuracy improves if you know what your yield potential is going to be at the end of the season. You can do your planning for anticipated management at the beginning of the year, then reassess at sowing based on preseason rainfall, and during the season to determine whether to apply in-season foliar fungicides.

What the developers say

"YellowSpotWM is a decision support tool that assists growers and consultants in determining the best management strategy to reduce yellow leaf spot disease in wheat and increase profits. YellowSpotWM accounts for the major factors that influence yellow leaf spot severity. The user can specify factors relating to paddock selection, variety, seasonal conditions, prices and management options so that the output relates to their cropping circumstance. Therefore, the user can explore their options for disease control and understand the relative importance of each factor."

Where can I download YellowSpotWM?

Visit the app store on your tablet and search "YellowSpotWM". Note: this app is only available on tablets to ensure full functionality.

MyCrop apps

The MyCrop Apps are a toolkit for agronomists which help diagnose symptoms on plants. The suite covers wheat, barley, oats, canola, lupin and field pea.

When should I use MyCrop?

Developed for WA but can be used to help narrow down what is causing symptoms on plants. Always follow up with local knowledge to confirm. It can be a bit difficult to understand how the app narrows down potential causes of symptoms but once understood can be useful.

Where can I download MyCrop apps?

Available on both Apple and Android operating systems, visit the app store on your smartphone or tablet and search "MyCrop".

Blackspot manager

Blackspot manager is an alert service for growers and agronomists which provides a risk prediction for blackspot infection when sowing field peas.

When should I use Blackspot manager?

Use Blackspot manager to identify blackspot risk when sowing field peas. Alerts are received via SMS, email or by checking the DPIRD website. The model encourages users to delay sowing, but this can also be used to identify risk, and implement appropriate management at sowing, for example applying a seed treatment. The service is useful for districts which sow a reasonable area to field peas as they can prepare for higher (or lower) risk years depending on the forecast.

What the developers say

"Blackspot manager is a model that predicts the maturity and release of spores using weather data from the nearest weather station. Where paddock rainfall is less than indicated by the nearest weather station, the probability of severe black spot may be higher. Predictions are based on the assumption that the location receives at least one rainfall event in excess of 3.5mm weekly."

How do I subscribe?

To subscribe to the free blackspot SMS or email alert service, text 'blackspot', your name and nearest weather station to 0475 959 932 or email Blackspot.Manager@dpird.wa.gov.au

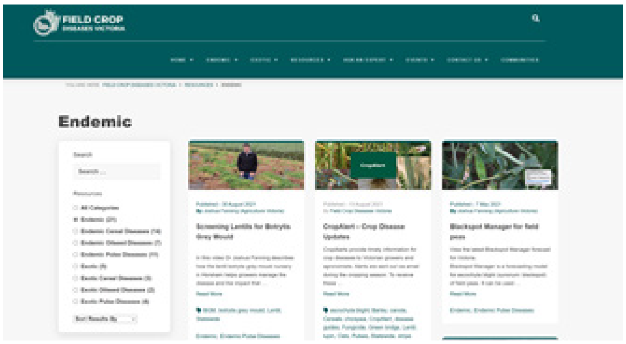
KEY WEBSITES

Field Crop Diseases Victoria

Field Crop Diseases Victoria is the place to be to gain recent and up to date information, assistance and expert advice on both endemic and exotic field crop diseases for the Victorian grains industry.

Access the “Identification and management of field crop diseases in Victoria” and the “Victorian guide to exotic pests and diseases of grain crops”

Visit extensionaus.com.au/FCDVic

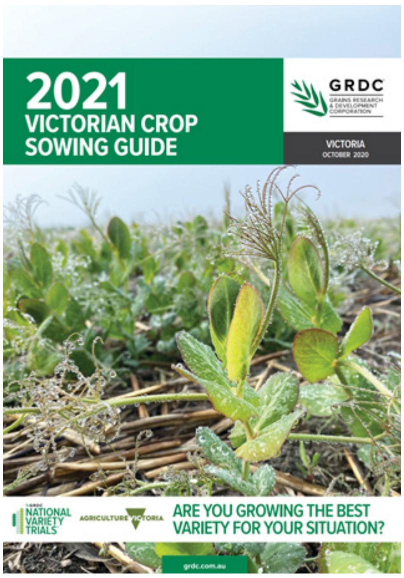


PREDICTA®B soil testing webpage

This page has sampling protocol documents for those who need a refresher plus PREDICTA®B maps for soil-borne diseases are also updated every year post sowing, highlighting the main areas of concern. Visit pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b or search ‘PREDICTAB’.

Victorian Crop Sowing Guide

Keep up to date with the latest varieties with a current Victorian Crop Sowing Guide at grdc.com.au/victorian-crop-sowing-guide. Other states and crop types can be found here https://grdc.com.au/resources-and-publications/all-publications/nvt-crop-sowing-guides



Agriculture Victoria Website

The Agriculture Victoria website houses Victorian AgNotes on cereal and pulse diseases and also provides access to the cereal and pulse disease guides which provide the current disease ratings. Visit https://agriculture.vic.gov.au/biosecurity/plant-diseases/grain-pulses-and-cereal-diseases and drill down.

Rust Pathotype Survey

To support the monitoring of rust isolates in Australia sent infected leaves in paper envelopes (do not use plastic wrapping or plastic lined packages) along with your contact details and, if possible, include the latitude and longitude of the sample location to:

University of Sydney
Australian Rust Survey
Reply Paid 88076
Narellan NSW 2567

Further instructions can be found at the University of Sydney cereal rust research website.

www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/cereal-rust-research/rust-reports.html

AFREN | Australian Fungicide Resistance Extension Network

Visit: afren.com.au

Supported by the GRDC, the Australian Fungicide Resistance Extension Network (AFREN) brings together regional plant pathologists, fungicide resistance experts and communications and extension specialists to develop and deliver fungicide resistance resources to growers and advisers across the country.

SOCIAL MEDIA

Social media feeds are a great way to scan what is happening, and the latest information being released without having to drill down until you see something you are interested in.

Researchers in Victorian Crop Disease research to keep an eye out for:

Grant Hollaway @Grant Hollaway – Leader of the cereal and pulse pathology programs for Agriculture Victoria in Horsham.

*Joshua Fanning @FanningJosh_* - Agriculture Victoria pulse and soil-borne disease researcher based in Horsham.

Luise Fanning @LuiseFanning – Diagnostician and plant pathologist for Agriculture Victoria based in Horsham.

Mark McLean @msmclean777 – Agriculture Victoria pathologist developing disease management strategies for barley, wheat and oats in Victoria.

Steve Marcroft @Steve_Marcroft – Canola disease expert. Follow to keep up with the latest in blackleg and other canola diseases.

Hari Dadu @Imharidadu – Agriculture Victoria pathologist developing disease management strategies for wheat and oats in Victoria.

Melissa Cook @Meleplantpath – Agriculture Victoria pathologist developing disease management strategies for wheat in Victoria.

Other key twitter accounts to follow

Agriculture Victoria Grains *@VicGovGrains* - A feed of the latest grains industry news & events from Agriculture Victoria. A more filtered feed for grains specific content than the general Agriculture Victoria channels.

GRDC @theGRDC - Feed of the latest research, development and extension, news and events from the Grains Research and Development Corporation.

GRDC South @GRDCSouth - Latest research outcomes, trial results, news & events specific to growers, advisors & industry in the GRDC Southern region.

Field Crop Diseases Victoria @VicCropDiseases – Twitter feed from the extensionAUS Victorian Field Crop Diseases, bringing together Victorian field crop diseases experts to you as part of a Community of Practice.

GLOSSARY

KEY DIAGNOSTIC FEATURES

SIGNS OF COMMON DISEASES

The more common diseases are likely to include the presence of one or some of the following:

- fungal fruiting structure such as pycnidia
- mycelium (fungal growth) in tissue
- bacterial ooze or bacteria in tissue
- insects – mites or aphids
- nematodes – check if there are cysts on the roots
- higher plant parasites – some, for example, branched broomrape (Orobanche ramosa), are only attached to roots.

FUNGI (MOST COMMON PLANT PATHOGEN)

Symptoms can be extremely diverse and difficult to generalise. They may include:

- mycelium (fungal growth); often in the lesions
- fruiting structures, such as pycnidia, may be present on plants, stubble, or in the soil
- isolation from infected tissue may be necessary; beware of secondary organisms developing on tissue killed by other

BACTERIA

- leaf spot often are water-soaked; may have bacterial ooze
- presence of bacteria in young infected tissue
- there are a number of bacterial wilt and gall diseases.

GUTTATION INJURY (EXUDATION OF DROPS OF SAP ON THE TIPS OR EDGES OF LEAVES)

- tip and margin of leaf burnt
- usually occurs after a succession of warm days and cool nights
- soil abundantly moist and fertile.

INSECTS AND MITES

This can include a great variety of symptoms, such as:

- tissue malformation and ‘hopper’ burns are common
- presence of known parasitic insects such as aphids or mites
- plants usually recover after the pest has been eliminated.

NEMATODES

- plants are often stunted and yellowed
- galls, knots or lesions on leave or roots; the latter may be decayed or distorted in other ways
- presence of nematodes with stylets in or on tissue
- presence of cysts on the roots.

HERBICIDE DAMAGE

- Symptoms are diverse and depend on type of herbicide, often with pre-emergence treatments injuries originate at roots. Symptoms may include root thickening, generalised necrosis extending up the stem, on leaves, marginal necrosis, necrotic and chlorotic areas, cupping and shoe string. There may be also epinasty and rosetting. These latter symptoms are associated with hormonal type materials.
- Patterns in the field may correlate to row treatment of previous year’s crop. Injury may vary with soil type, topography and uneven application.
- Examine other plants for similar symptoms.

KEY DIAGNOSTIC FEATURES

MINERAL DEFICIENCIES

- Various symptoms though interveinal chlorosis, (compare with photographs in Winter Cereal Nutrition: The UTE Guide available from the GRDC www.grdc.com.au/). Recovery usually occurs following injection or spraying with suspected deficient elements.
- Compare symptoms in combination with a soil nutrient and/ or a plant tissue test.
- Recovery usually only occurs following injection or spraying with suspected deficient elements.

MINERAL EXCESS AND SPRAY DAMAGE

(see also saline soils)

- leaves often have marginal necrosis and dull brown spotting
- excess mineral symptoms are not a diagnostic as are deficiency symptoms.

GENETIC ABERRATION

- mosaic leave symptoms similar to those caused by some viruses and some deficiencies e.g. Yellowing in Kord CL Plus, Grenade CL Plus, Justica CL Plus, Axe, Gladius and Correll wheat varieties
- disease does not spread in the field
- appears in most environments and locales
- non transmissible; often traceable to certain clones or varieties
- Plant Hormones 2,4-D, etc.
- usually profound distortions of leave
- similar symptoms on different broad-leaved species in the case of 2,4-D
- plants often recover.

VIRUSES

- often chlorotic and necrotic leaf patterns; occasionally leaf, shoot and fruit distortions (symptoms may be masked at different times of season or disappear entirely after shock stage)
- disease often spreads in the field
- may be randomly distributed in the field or at edges of field near perennial source of virus
- often on a variety of sites
- absence of known toxic insects
- unless symptoms are clearly characteristic of a known virus, then laboratory testing will be necessary
- with sap transmission, beware of relying exclusively on demonstration of local lesions, a bacterium may be involved.

SALINE SOILS

Obvious symptoms may be lacking even with considerable decrease in yield

- leaves, stem and fruits are usually smaller than normal
- leaves are characteristically deeper blue-green
- damage usually occurs in arid or semi-arid regions
- presence of indicator plants that tolerate high saline soils
- test measuring electrical conductivity of soil solutions is necessary to determine degree of salinity.

WEATHER – FROST INJURY

- correlate with local weather
- plants growing in low areas of the paddock
- marginal and interveinal leaf spotting; young tender parts of plants usually affected
- distorted growth occurs when buds are injured particularly.

WEATHER – EXCESS WATER

- correlate with weather and low spots in field
- particularly severe on heavy soils and high temperatures.

TOXIC PLANT RESIDUES

- primary root of seedlings inhibited and roots have surface lesions in some cases
- excess plant residue in soil
- disease often associated with heavy, poorly aerated, waterlogged soils and relatively cool temperatures
- occurs on several unrelated species
- may be a general decrease in plant size.

KEY TERMS

Ascospores: Sexual spore borne in an ascus

Ascostroma (pl. ascostromata): A fruiting body containing bitunicate (doublewalled) asci in locules (cavities); usually dark with multiple locules, but sometimes single (see pseudothecium)

Ascus (pl. asci): Sac-like structure containing ascospores (typically eight) and usually borne in a fungal fruiting body

Asexual: Vegetative; without sex organs, gametes, or sexual spores; the imperfect or anamorphic stage of a fungus

Autoecious: In reference to rust fungi, producing all spore forms on one species of host plant (see heteroecious)

Basidium (pl. basidia; adj. basidial):Specialized cell or organ, often club-shaped, in which karyogamy and meiosis occur, followed by production of externally-borne basidiospores that are haploid. There are several types of basidia

Basidiospore: Haploid (1N) sexual spore produced on a basidium

Chlamydospores: Thick-walled or double-walled asexual resting spore formed from hyphal cells (terminal or intercalary) or by transformation of conidial cells that can function as an overwintering stage

Coenocytic: Having multiple nuclei embedded in cytoplasm without cross walls; nonseptate

Conidium (pl. conidia): Asexual, non-motile fungal spore that develops externally or is liberated from the cell that formed it

Dikaryon (adj. dikaryotic): Having two sexually compatible haploid nuclei per cell, that divide simultaneously; this phase is called the dikaryophase

Diploid: Having two complete sets of chromosomes (2N chromosomes) (see haploid, polyploid)

Ergosterol biosynthesis: The chemical reactions and pathways resulting in the formation of ergosterol, a sterol required for fungal cell membrane structure and function

Flagellum (pl. flagella): Appendage of a motile cell, bacterium or zoospore that provides locomotion

Haploid: Having a single complete set of chromosomes (see diploid, polyploid)

Haulm: Stem or stalks collectively

Heteroecious: Pertaining to a rust fungus requiring two unrelated host plants for completion of its life cycle (see autoecious)

Hymenium: Continuous, spore-bearing layer of a fungus fruiting body

Hypha (pl. hyphae; adj. hyphal): Single, tubular filament of a fungal thallus or mycelium; the basic structural unit of a fungus

Karyogamy: The fusion of nuclei

Meiosis: Process of nuclear division in which the number of chromosomes per nucleus is halved, i.e. Converting the diploid state to the haploid state (see mitosis)

Mitosis: Nuclear division in which the chromosome number remains the same (see meiosis)

Motile: Capable of self-propulsion by means of flagella, cilia, or amoeboid movement

Mycelium: Mass of hyphae constituting the body (thallus) of a fungus

Nonseptate: Having no cross walls; lacking septa; coenocytic, aseptate

Oomycetes: Class of fungal-like organisms typically with nonseptate mycelium, asexual sporangia and zoospores, and sexual oospores

Oospore: Thick-walled, sexually-derived resting spore of oomycetes

Perithecium (pl. perithecia): Flask-shaped or sub-globose, thin-walled fungus fruiting body (ascocarp) containing asci and ascospores

Polyploidy: Having three or more complete sets of chromosomes (see haploid, diploid)

Promycelium (pl. promycelia: In rust and smut fungi, a germ tube issuing from the teliospore and bearing the basidiospores

Pseudothecium (pl. pseudothecia): Perithecium-like fruiting body containing asci and ascospores dispersed rather than in an organized hymenium; an ascostroma with a single locule (cavity) and containing bitunicate (double-walled) asci

Pycnidium (pl. pycnidia): Asexual, globose or flask-shaped fruiting body of certain imperfect fungi producing conidia

Saprophyte (adj. saprophytic; syn. saprobe): Organism that obtains nourishment from nonliving organic matter

Sclerotium (pl. sclerotia): A vegetative resting body of a fungus, composed of a compact mass of hyphae with or without host tissue

Sporangiopore: Non-motile, asexual spore that is borne in a sporangium

KEY TERMS

Sporangium (pl. sporangia): Sac-like fungal structure in which the entire contents are converted into an indefinite number of asexual spores

Teliospore (sometimes called teleutospore): Thick-walled resting or overwintering spore produced by the rust and smut fungi which germinate to form a promycelium (basidium) in which meiosis occurs Tubulin a protein that is the main constituent of the microtubules of living cells

Urediniospore (also urediospore, uredospore): The asexual, dikaryotic, often rusty-coloured spore of a rust fungus, capable of infecting the host plant on which it is produced

Uredinium (also uredium; pl. uredinia): Fruiting body (sorus) of rust fungi that produces urediniospores

Zoospore: Fungal spore with flagella, capable of locomotion in water

Note: This glossary was adapted from several sources including Plant Pathology (4th Ed. GN Agrios, 1997, Academic Press)