Canola can be infected by a number of pathogens in Australia, ranging from root rots to leaf disease and crown to stem infections. As with all diseases, their presence and severity depends on plant susceptibility, presence of the pathogen and favourable climatic conditions. Generally, fungal diseases such as blackleg and Sclerotinia are more damaging in higher rainfall regions, but if unseasonably high rainfall occurs in lower rainfall regions these areas may also experience high disease levels. Disease control varies for each pathogen but generally variety resistance, crop production practices and fungicides are used, either alone or in 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.

Blackleg caused by the fungus *Leptosphaeria maculans* is the most damaging disease of canola (*Brassica napus*) in Australia and most canola producing countries throughout the world. Sclerotinia stem rot and damping-off are other damaging diseases. Alternaria, white leaf spot, downy mildew and viruses may be common in some seasons but they do not normally cause significant crop damage. Clubroot has recently been identified in New South Wales and Victoria.

### COMMON DISEASES OF CANOLA

Refer to the following sections in this chapter for symptoms and management practices.

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**Blackleg**

Blackleg, caused by the fungus *Leptosphaeria maculans*, is the most serious disease of canola in Australia. The severity of blackleg has risen in recent years due to increased area and intensity of production. Although not common, yield losses of 50 per cent and greater have been recorded in some seasons with up to 90 per cent yield loss occurring in cases where *L. maculans* has overcome major blackleg resistance genes within certain varieties.

**Symptoms and disease cycle**

Blackleg survives on canola stubble, producing fruiting bodies that contain large quantities of airborne spores (capable of travelling several kilometres). These dark-coloured raised fruiting bodies (pseudothecia) can be seen easily with the naked eye (see pictures below). Date of spore release from the stubble depends on autumn rainfall. Higher rainfall results in earlier spore release and, consequently, may lead to increased disease severity.

In the autumn and winter, rainfall triggers spore release from the stubble. Within two weeks of spores landing on canola cotyledons and young leaves, clearly visible off-white coloured lesions develop. Within the lesion pycnidial fruiting
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Bodies (dark coloured dots) release rain-splashed spores (see pictures left). Once the lesion has formed, the fungus grows within the plant’s vascular system to the crown where it causes the crown of the plant to rot, resulting in a canker. Severe canker will sever the roots from the stem, whereas a less severe infection will result in internal infection of the crown restricting water and nutrient flow within the plant.

In recent years, blackleg symptoms have also been found in the plant roots. This root infection, in severe cases, appears to cause the entire plant to die prematurely. The root rot form of the disease is caused by the same blackleg strains that cause the stem canker. Management practices are the same for both forms of the disease.

Management

Blackleg is the most severe disease of canola but it can be successfully managed by:
- growing resistant varieties;
- avoiding the previous year’s stubble; and
- using fungicides in high-risk situations.

Choose a variety with adequate blackleg resistance – the best defence against blackleg is varietal resistance. The Canola Association of Australia (www.canolaaustralia.com) publishes blackleg resistance ratings of all Australian canola varieties in February each year.

Blackleg rating data are collected each year from a number of sites in NSW, Victoria, South Australia and Western Australia. Consult the latest guide as blackleg resistance ratings can change from one year to the next due to changes in the frequency of different blackleg strains.

Isolate this year’s crop from last year’s canola stubble – varietal resistance alone is not enough to protect your crop from yield loss caused by blackleg. It is also crucial to avoid high levels of disease pressure by reducing exposure to large inoculum loads. In most situations, more than 95 per cent of all blackleg spores in the atmosphere originate from canola stubble that was crop in the previous year. Older stubble does not produce many blackleg spores. Disease pressure falls markedly in the first 200 metres away from last year’s stubble and then continues to decline up to 500 m. Therefore, sow crops away from last year’s canola stubble. There appears to be little advantage in increasing the isolation distance past 500 m.

Stubble management such as raking and burning or burial can reduce disease pressure by up to 50 per cent. However, it is not known how much stubble must be destroyed to achieve an economic benefit through decreased blackleg severity. Extending the time between canola crops in a paddock rotation does not reduce disease severity due to the wind-borne nature of the spores. Crops that have been sown into two-year-old stubble do not have more disease than crops sown in paddocks with a three-year break from canola.

Some growers have found that planting all their canola crops on one part of the farm in one year and then on the opposite side of the farm in the next year ensures isolation between the crop and the last year’s stubble. Anecdotal
to provide an economic benefit. The economic viability of high disease pressure then fungicides are more likely or if varieties with good resistance are sown into situations blackleg resistance ratings are sown in higher rainfall areas give an economic return. Generally, if varieties with low attack from blackleg. However, fungicides do not always seedlings, which is when the plant is most vulnerable to blackleg. Both fungicides give initial protection to canola fertiliser (active ingredient flutriafol) reduce the severity of seed dressing (active ingredient fluquinconazol) or on the impacts on canola yields.

Evidence suggests that this practice has had positive impacts on canola yields.

Consider fungicide use – fungicides applied as a seed dressing (active ingredient fluquinconazol) or on the fertiliser (active ingredient flutriafol) reduce the severity of blackleg. Both fungicides give initial protection to canola seedlings, which is when the plant is most vulnerable to attack from blackleg. However, fungicides do not always give an economic return. Generally, if varieties with low blackleg resistance ratings are sown in higher rainfall areas or if varieties with good resistance are sown into situations of high disease pressure then fungicides are more likely to provide an economic benefit. The economic viability of using fungicides in other situations should be determined.
by monitoring the number of cankered plants (see previous picture) in the current season’s crop. If more than three per cent of plants are cankered then the use of a fungicide may be warranted in future seasons.

**Sclerotinia stem rot**
Sclerotinia stem rot caused by the fungus *Sclerotinia sclerotiorum* is a disease that attacks many species of broadleaf plants, including canola, peas, beans, sunflowers, pasture species, weeds and lupins. The disease is sporadic, occurring when environmental conditions are favourable for infection. Prolonged humid (wet) conditions during flowering favour disease development, and yield losses as high as 24 per cent have been recorded in Australia. Anecdotal evidence suggests that losses could be greater in the higher rainfall regions of New South Wales.

**Symptoms**
Disease symptoms appear in the crop from late flowering onwards, two to three weeks after infection. The fungus produces light-brown discoloured patches on stems, branches and pods. These lesions expand and take on a greyish-white colour. Infected canola plants ripen earlier and stand out as bleached or greyish coloured plants among green healthy plants. The bleached stems tend to break and shred at the base. When an infected canola stem is split open, hard black bodies called sclerotia can usually be found inside. Sclerotia are the resting stage of the fungus and resemble rat droppings. They are dark coloured, either round like canola seed, rod, cylindrical or irregular in shape; 2–4 mm in diameter and up to 20 mm long. In wet or humid weather, a white growth resembling cotton wool can develop on lesions and sclerotia may also develop in this white growth.

**Disease cycle**
Sclerotia remain viable for many years in the soil. When weather conditions are favourable, they germinate to produce small mushroom-shaped structures called apothecia. These apothecia produce thousands of air-borne spores that can be carried several kilometres by the wind. Spores land on canola petals, germinate, and then use the petal as a nutrient source producing a fungal mycelium. When the petals fall at the end of flowering, they often get caught in the lower canopy of the crop allowing the fungus to grow from the petal into the plant. The canola flowering period is therefore the critical time for Sclerotinia infection. Wet weather at flowering enhances germination of the spores and infection.

**Management**
Results from overseas show that the timely application of fungicides during flowering reduces yield losses. In Australia, Rovral® liquid fungicide (active ingredient iprodione) and Sumisclex® broadacre fungicide (active ingredient procymidine) are registered for control of Sclerotinia on canola crops.

Use good quality seed that is free of sclerotia. Although there is no canola seed certification for Sclerotinia in Australia, careful inspection of seed before sowing will determine if high levels of sclerotia are present.

Sclerotinia does not affect cereals and sclerotia density will decline without a host. A three to four-year break between canola crops and other susceptible plants reduces disease severity.

Control broadleaf weeds to prevent build-up of inoculum and avoid sowing canola next to paddocks that were severely infected with Sclerotinia in the previous season.
Alternaria leaf and pod spot (black spot, dark leaf spot, Alternaria blight)

Alternaria is usually caused by the fungal pathogen *Alternaria brassicaceae* and occasionally by *Alternaria brassicicola*. Canola cultivars are more resistant to *A. brassicicola*. The severity of the disease varies between years and locations depending on seasonal conditions. Warm humid conditions during spring favour the disease. Yield loss is unusual and is normally associated with the shattering of infected pods. If infected seed is sown, seedling blight may occur (refer to damping-off section, page 64).

**Symptoms**

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 occur 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. Severe pod infections may cause seed to shrivel and the pods to prematurely ripen and shatter. Stem spots are elongated and almost black. Pod symptoms of Alternaria are similar to those of blackleg and the two can be difficult to distinguish in the field.

**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. Wind-blown spores cause initial crop infections. 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 further spores and infections can then be spread throughout the crop by either 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 warm and dry throughout podding, which is unfavourable for prolonged infection.

**Management**

- Alternaria is very common in canola crops but is not usually severe enough to warrant control.
- No registered fungicide seed treatments are available for Alternaria in Australia.
- If pods were infected in the previous season, obtain fresh disease-free seed.
- 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.

Clubroot in canola and juncea canola

Clubroot is caused by the soilborne fungus *Plasmodiophora brassicaceae*. The disease occurs worldwide and only affects plants in the Cruciferae family including canola, juncea canola (mustard), cabbage, cauliflower, brussels sprouts and broccoli.

In Australian vegetable brassicas, clubroot is widespread and causes significant yield losses. The Australian oilseed industry has been somewhat protected from clubroot as the major production areas for vegetable and oilseed brassicas are usually separated from one another. As well, most Australian pathotypes of clubroot are only able to cause disease in the warmer months and require irrigation water for dispersal, except for Tasmania and some parts of NSW where disease is observed year round.

**Symptoms**

Swollen, galled roots are the most typical symptom of infected plants. These range from tiny nodules, to large, club-shaped outgrowths. The galls are, at first, firm and white but become soft and greyish-brown as they mature and decay. Affected roots have an impaired ability to transport water and nutrients.
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Disease cycle
Resting spores of the fungus can survive in soil for many years, even in the absence of a susceptible host. Infection can occur at any stage of growth and is restricted to the roots. In the presence of susceptible roots, the spores germinate and release tiny motile spores that swim in free water to the surface of the rootlets, penetrate and form a fungal colony (plasmodium) inside the root cells. The fungus causes cells to enlarge and divide rapidly, resulting in the characteristic galls. Late in the season, resting spores develop in the infected roots and are released into the soil as the galls decay. Fields become infested mainly by the movement of soil on cultivation equipment and by seedling transplants.

Management
Several methods of control have been developed in the Australian vegetable Brassica industry that may be useful for oilseed Brassicas.
- Five-year rotation: infested fields are kept free of susceptible crops and weeds for at least five years to allow sufficient natural decay of the long-lived spores.
- Equipment movement: thoroughly clean cultivating equipment before moving it from infested to non-infested areas.
- Liming: clubroot thrives in acid soils (pH < 7.0), liming to increase soil pH (7.0–7.5) has been successful for vegetable Brassicas but would be cost prohibitive in most areas where oilseed Brassicas are grown.

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., Alternaria spp. and the blackleg fungus, Leptosphaeria maculans, can also cause damping-off. Symptoms and crop management are similar for all these pathogens so they are grouped together under the term ‘damping-off’.

Symptoms
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). If affected plants survive, they are normally stunted and may flower and mature prematurely. Once past the seedling stage canola plants are not adversely affected by damping-off. Both pre and post-emergence damping-off occurs in patches and affected areas can spread quickly during cold wet conditions. Leaves of plants affected by post-emergence 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.

Disease cycle
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. Dry 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 weak pathogens (except blackleg) only able to infect young succulent tissue. At the two to four-leaf stage, below-ground parts 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...
Application of seed fungicide treatments at sowing can reduced on a regular basis. Downy mildew does not usually affect yield so control is generally warranted unless plant densities are severely reduced or if dew periods have been long. 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 leaf beneath these spots, if conditions have been moist enough to cause yield loss. Downy mildew is rarely found beyond the rosette stage and crops normally grow away from it with the onset of warmer weather.

### Symptoms
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, if conditions have been moist or if dew periods have been long. 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 to develop a yellow-red colour.

### Disease cycle
The fungus, which is both soil and seed-borne, can persist in the soil for a long time. Cool, wet weather favours infection and, under ideal conditions, new infections can develop in as little as three to four 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 is 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.

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**Viruses**
The three viruses that infect Australian canola are: Beet western yellows virus (BWYV), Cauliflower mosaic virus (CaMV) and Turnip mosaic virus (TuMV). These viruses are very widespread and surveys have shown that in some situations most crops have some infected plants. As with most viruses, yield loss is very hard to measure so the actual damage to crop production is difficult to determine.

### Symptoms
Symptoms vary widely, from no visual indication to stunted red plants and stiffening of leaves for BWYV, chlorotic ring spots and mottling for CaMV and yellow mosaic patterning and tip necrosis for TuMV.

### Disease cycle
These viruses are not seed-borne. They survive in weeds or volunteer host plants during the summer and are then spread from these plants into crops by aphids which act as the vector for transmission. BWYV is termed a persistent virus. Persistent viruses are carried in the aphid’s body and can be transmitted to healthy plants during feeding. The aphid will often remain infectious throughout its life. CaMV and TuMV are non-persistent viruses, being retained in the aphid mouthparts for less than four hours.

Autumn is the critical infection period, so the earliest-sown crops usually have the highest infection incidence. Yield loss is greater in crops that have been infected as seedlings. Infections can occur past the rosette stage of canola growth but these probably have little effect on yield.

### Management
- Control broadleaf weeds (especially over summer) as they can act as reservoirs for viruses.
- Sow at recommended times; earlier sown crops usually have a greater incidence of viral infection.
- Monitor aphid numbers in crops (aphids usually found under leaves) and consider using an insecticide as a foliar (active ingredient pirimicarb) or seed treatment (active ingredient imidacloprid) to control aphids on seedlings and young canola plants.

### 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.

### Symptoms
Leaf, stem and pod lesions are greyish-white to light brown. Unlike blackleg lesions, white leaf spot lesions do not contain pycnidial fruiting bodies (black dots) and usually have a more granular surface. Leaf lesions often have a brown margin when they mature; they can be up to 1 cm in diameter and often join to form large irregular shaped...

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lesions. Nutrient deficient crops have been reported to be more severely affected by the disease. In severe epidemics, infections can defoliate susceptible varieties.

**Disease cycle**
The fungus survives on canola stubble as thick-walled mycelia. When prolonged wet weather conditions prevail in 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. Crop rotation and isolation from the previous year's canola stubble will prevent infection from wind-borne spores. Control cruciferous weeds and volunteer canola, and provide adequate nutrition to reduce crop stress.

**White rust or staghead**
White rust is caused by the fungus *Albugo candida*. The disease is uncommon in Australian canola varieties but does infect *B. juncea* (juncea canola / Indian mustard) and the weed shepherd's purse (*Capsella bursa-pastoris*).

**Symptoms**
White to cream coloured pustules form on the underside of leaves and on floral parts. These pustules rupture the host epidermis exposing a white chalky dust. On the upper surface of the leaves, the infected areas are bleached and thickened. Systemic infections of the growing tips and flower heads give rise to stagheads. Stagheads are very conspicuous in the crop as swollen, twisted and distorted flower heads that produce little to no seed and become brown and hard as they mature (see photo). Symptoms for white rust should not be confused with symptoms of severe calcium deficiency that cause flowering stalks to collapse, resulting in the withering death of the flower head (see picture).

**Disease cycle**
Resting spores (oospores) of the fungus can survive in infected plant material or as a seed contaminant for many years when conditions remain dry. When conditions become moist the resting spores are able to directly infect plants. However, they usually produce tiny motile spores that can swim in free water to infect seedlings, causing cream-white pustules to form. Inside the pustules, new swimming spores are formed and then distributed throughout the canopy by rain splash to form secondary infections. They do this by growing through stomata into adjacent cells, causing systemic infections and subsequent stagheads if the growing tips of plants become infected. The resting spores can be formed in any infected tissues but are present in larger numbers in stagheads. When the crop is harvested, stagheads break and release resting spores that contaminate harvested seed or blow away to contaminate the soil.

**Management**
- Obtain seed from disease-free or low-disease crops.
- Control cruciferous weeds.
- Extended rotations will allow crop residues to decompose and reduce the risk of infections.
- Consider growing *B. napus* rather than *B. juncea*.