NORTHERN
FEBRAURY 2017

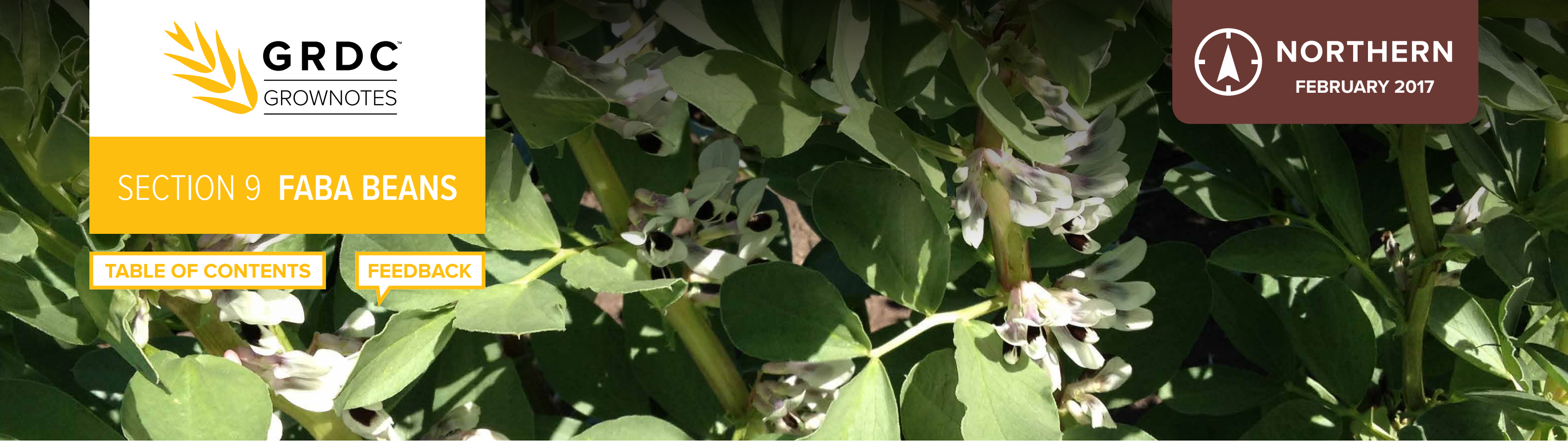
GRDC GROWNOTES™

GRDC™ GRAINS RESEARCH & DEVELOPMENT CORPORATION

FABA BEAN

SECTION 9

DISEASES



Diseases

MORE INFORMATION

[Pulse Australia: Visual quality charts]

9.1 Fungal disease management strategies

Disease management in pulses is critical, and relies on an integrated management approach involving variety choice, crop hygiene and strategic use of fungicides. The initial source of the disease can be from the seed, the soil, the pulse stubble and self-sown seedlings, or in some cases, other plant species. Once the disease is present, the source is then from within the crop itself.

Note that the impact of disease on grain quality in pulses can be far greater than yield loss. This must be accounted for in thresholds because in pulses, visual quality has a significant impact on market price. Examples are Ascochyta blight in most pulses, and *Pea seed-borne mosaic virus* (PSbMV) in field peas.

A plant disease may be devastating at certain times and yet, under other conditions, it may have little impact. The interaction of host, pathogen and environment are all critical points in disease development, and all can be represented by the classical disease triangle (Figures 1 and 2). Diseases such as Ascochyta blight and Phytophthora root rot can cause total crop failures very quickly, whereas Botrytis grey mould and root lesion nematodes may 'tick' away over the season and mask their true effects on crop performance and yield.

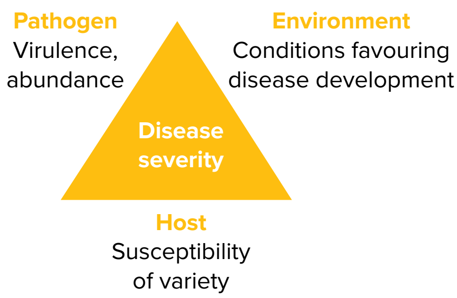


Figure 1: *The fungal disease triangle (Agrios 1988).*

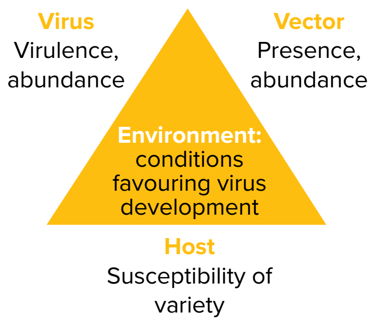


Figure 2: *The virus (and some bacterial) disease triangle (Jones 2012).*

Disease management should be a consideration when planning any rotation, particularly at the beginning of the season. This is especially important for faba beans where the first action of defence against diseases begins with paddock selection. Other criteria such as seed quality and treatment are also vitally important.

Determine which diseases are the highest priorities to control in the pulse crop being grown, and sow a variety that is resistant to those diseases if possible. Strategic fungicide application combined with paddock selection is also part of an overall program to minimise disease impact. Fungicide disease control strategies alone may not be economic in high-risk situations, particularly if susceptible varieties are grown.

Variety selection

Growing a resistant variety reduces the risk and reliance on foliar fungicides.

Distance

Proximity to stubble of the same pulse from the previous year will affect the amount of infection for some diseases. Aim for a separation distance of at least 500 m.

Paddock history and rotation

Aim for a break of at least 4 years between planting the same pulse crop. A high frequency of crops such as lentils, faba beans, vetch, field peas, chickpeas, *Lathyrus* or clover pasture puts pulses at greater risk to multi-host disease pathogens such as *Phoma*, *Sclerotinia* and *Botrytis*. Ascochyta blight species are more specific to each pulse crop but 3–4 year rotations are still important. Canola can also increase the risk of Sclerotinia rot.

Hygiene

Take all necessary precautions to prevent the spread of disease. Reduce last year's pulse stubble if erosion is not a risk and remove self-sown pulses before the new crop emerges.

Seed source

Use seed from crops where there were low levels of disease, or preferably no disease, especially at podding. Avoid sowing seed that is known to have disease infection, particularly the susceptible varieties. Have seed tested for disease status where recommended.

Fungicide seed dressings

Seed dressings are partially effective early in high disease-risk situations, particularly for diseases such as seed-borne Botrytis grey mould, Phoma blight and Ascochyta blight. They are not effective on viruses and bacterial diseases.

Sowing date

To minimise foliar disease risk, do not sow too early to avoid excessive vegetative growth and early canopy closure. Early crop emergence may coincide with greater inoculum pressure from old crop residues nearby. Aim for the optimum sowing window for the pulse species and your district.

Sowing rate

Aim for the optimum plant population (depending on region, sowing time, crop type, variety), as denser canopies can lead to greater disease incidence. Adjust the seeding rate according to seed size and germination.

Sowing depth

Sowing deeper than is usual practice will help reduce the emergence of infected seedlings. The seeding rate must be adjusted upwards to account for the potential of a lower emergence and establishment percentage.

Foliar fungicide applications

Disease-resistant varieties do not require the intense regular foliar fungicide program that susceptible varieties need to control foliar diseases. Some pulses may require fungicide treatment for Botrytis grey mould if a dense canopy exists. Successful disease control with fungicides is dependent on timeliness of spraying, the weather conditions that follow, and the susceptibility of the variety grown. Monitoring for early detection and correct disease identification is essential. Correct fungicide choice is also critical.

Mechanical damage

Any physical damage due to excessive traffic, wind erosion, frost, hail, post-emergent rolling or herbicide damage can lead to the increased spread of foliar disease in pulses, particularly bacterial blight in peas.

Controlling aphids

This may reduce the spread of viruses, but not eliminate them. Protective insecticide treatments are unlikely to be successful if applied strategically, or economic if applied regularly. Usually the virus spread has occurred by the time the aphids are detected.

Harvest management

Early harvest will help reduce disease infection of seed, and is also important for grain quality and to minimise harvest losses. Crop desiccation enables an earlier harvest, reduces moisture risk and adverse weather risks. Moisture contents of up to 14% are allowable at delivery. Do not desiccate prior to physiological maturity as this can affect grain quality. [1]

9.2 Integrated pest management

Integrated pest management (IPM) is a multi-layered approach of crop management to reduce chemical inputs and solve ecological problems. Although originally developed for insect pest management, IPM programs now encompass diseases, weeds and other pests.

Integrated pest management is performed in three stages: prevention, observation, and intervention. It is aimed at significantly reducing or eliminating use of pesticides while managing pest populations at an acceptable level.

An IPM system is designed around six basic components.

1. Acceptable disease levels
- Emphasis is on economical control, not eradication.
- Elimination of the disease is often impossible, and can be economically expensive and environmentally unsafe.
- Integrated pest management programs work to establish acceptable disease levels (action thresholds) and then apply controls if those thresholds are likely to be exceeded. Thresholds are disease- and site-specific. What is acceptable at one site may not be acceptable at another site or crop. By allowing some disease to be present at a reasonable threshold means that selection pressure against resistance is reduced.

2. Preventive cultural practices
- Use varieties best suited to local growing conditions and with adequate disease resistance.
- Maintaining healthy crops is the first line of defence, together with plant hygiene and crop sanitation (e.g. removal of diseased plants to prevent spread of infection). Crop canopy management is also very important in pulses, hence time of sowing, row spacing and plant density and variety attributes become important.

3. Monitoring
- Regular observation is the key to IPM.

1 Southern/Western Faba and Broad Bean—Best Management Practices Training Course. Module 3—Varieties. 2013. Pulse Breeding Australia.

- Observation is broken into inspection and then identification. Visual inspection, spore traps, and other measuring tools are used to monitor disease levels. Accurate disease identification is critical to a successful IPM program. Record-keeping is essential, as is a thorough knowledge of the behaviour and reproductive cycles of target pests.
- Diseases are dependent on both specific temperature and moisture regimes to develop (e.g. rust requires warm temperatures, Ascochyta blight often requires colder temperatures). Monitor the climatic conditions and rain likelihood to determine when a specific disease outbreak is likely.

4. Mechanical controls

- Burn or plough in pulse stubble, removing hay, cultivating self-sown seedlings.
- Should a disease reach unacceptable levels, or high inoculum loads are anticipated, then mechanical methods may be needed for crop hygiene.

5. Biological controls

- Crop rotation and paddock selection is a form of biological control.
- Also using crops and varieties with resistance to the specific disease is important. Other biological products are not necessarily available for disease control.

6. Responsible use of fungicides

- Synthetic pesticides are generally only used as required and often only at specific times in a disease life cycle.
- Fungicides that are applied as protection ahead of conditions that are conducive to disease (e.g. sustained rainfall) may reduce total fungicide usage. Timing is critical with foliar fungicides, and may be more important than the rate used. Protection is better than cure, because once the disease is established in the canopy there is an internal source of infection that is hard, or even impossible, to control with later fungicide applications. [2]

9.3 Key criteria and considerations

9.3.1 Risk assessment

Risk assessment is the prediction of likely damage from a faba bean disease. It can be used at the paddock, whole farm, regional, state or national level. The choice of variety, disease management options and fungicide availability are some of the factors determining risk. Seasonal conditions and sowing times have a huge impact on risk as well.

The distribution and dispersal (large-scale spatial patterns) of a pathogen contribute to the regional occurrence of a disease. This regional pattern has been evident in the chocolate spot epidemics in the different states in the early years of faba bean production using the variety Fiord. Even in 2010, early sowing in some areas exposed crops to early and sustained infection. In these intensive faba bean production areas, the build-up of fungal inoculum prior to the growing season, coupled with conducive weather conditions early and into the spring, were major factors leading to the rapid onset of disease across large geographic areas. However, in other areas where the early season conditions were also favourable for chocolate spot, crops did not suffer too badly. Why was this so? Increased distance of new crop from inoculum on infested stubble and old crop volunteers meant that the limited distribution of the fungus in these areas had less impact than in the more intensive systems.

Risk assessment relies on the actions of the grower, their confidence in forecasts, and their tolerance for accepting risk. To make decisions for pre-season disease management options, such as choosing the appropriate variety, growers need information about mid- to long-term disease risk. The risk of chocolate spot can be managed by pre- and post-planting operations. On the other hand, a disease such

2 Southern/Western Faba and Broad Bea— Best Management Practices Training Course. Module 3—Varieties. 2013. Pulse Breeding Australia.

as common root rots can only be managed by pre-planting decisions, i.e. marrying together information on crop history and seed treatment needs. As well, the risk of the occurrence of waterlogging and pooling water should be understood.

The history of faba bean production in Australia is relatively short, but we do now have experience and long-term records of production in adverse years. Moreover, it is likely that diseases are cyclical in nature, rather than being a 'given' year-in year-out, which goes hand in hand with our variable climate. It is evident that the risk of severe faba bean diseases is intimately linked with weather conditions (rainfall, humidity and temperatures).

Modelling can provide some predictive ability on both rainfall probability and on how a crop will perform under those conditions (in the absence of disease). If epidemiological data for specific diseases are included into the algorithms, powerful models can be constructed. However, modelling pulse disease in Australia, including faba bean, is in its infancy. However, we do have a good understanding of the epidemiology of the predominant diseases and their close association with weather conditions. Hence, fungicide protection applied before rainfall events is an integral part of an overall disease management strategy.

Significant pressure from a particular disease in the southern region is maybe 1-in-3-year event or maybe 1-in-5, based on current varieties, but varies with the location, disease and management strategies in place. Rust emerged as a significant factor in 2011, yet chocolate spot was relatively minor. In 2010, the opposite occurred. Fungicide product choice and timing had some influence on this though. Severe rust has likely been a 1-in-10-year occurrence, but protection is often applied when Ascochyta blight is being controlled. The experiences with the northern varieties Doza⒲ and Cairo⒲ demonstrate how vulnerable we are to Ascochyta blight if we do not have varietal resistance. Cercospora leaf spot is virtually an annual occurrence in southern bean crops where there has been a paddock history of beans.

Chocolate spot is a more regularly occurring disease, but it is manageable. Its risk cannot be predicted because of variable rainfall.

Ideally, chemical options should be seen as a last resort, rather than the primary strategy; they are often a crude substitute for intelligent planning. Fungicides are but one weapon in the arsenal and we need to be prudent in the way they are used. Our farming systems should prioritise disease prevention and protection over disease cures.

Knowing your paddock history, its layout (topography) and soil parameters will help you assess your level of risk.

9.3.2 Steps in risk assessment

Identify factors that determine risk:

- **Pathogen:** exotic *v*. endemic, biotypes, pathogenicity, survival and transmission, amenable to chemical management.
- **Host:** host range, varietal reactions, vulnerability, does susceptibility change with growth stage?
- **Environment:** weather dependency, interactions with nutrition, herbicides, other diseases, agronomic factors, e.g. planting depth, row spacing, no-tillage, soil conditions.
- **Risk management:** access to components of management plan; ease of implementing plan; how many options; cost of implementation.

Assess level of factors:

- **Pathogen:** level of inoculum, dirty seed, aggressiveness of isolate, weed hosts prevalent in paddock or nearby, paddock history.
- **Host:** how susceptible, nutritional status, frost susceptibility, herbicide susceptibility.

- **Environment:** length of season, likelihood of rain, drought, waterlogging, irrigation, availability of spray gear, paddock characteristics, herbicide history.
- **Risk management:** has it not yet been considered, a plan is being developed, or is a plan in place?

What risk level is acceptable?

- **High:** grower is prepared to accept substantial yield loss as potential returns are high and financial situation sound; crop failure will not affect rotation or other components of the farming system.
- **Low:** grower needs cash flow and cannot afford to spend much or lose the crop; failure seriously impacts on farming system.

9.3.3 Paddock selection

The selection of the most appropriate paddock for growing faba beans requires consideration of a number of important factors, many of which are related to the modes of survival and transmission of pathogens such as *Ascochyta fabae* or *Phoma medicaginis*.

- Rotation
  - » Develop a rotation of no more than 1 year of beans in 4 years.
  - » Plant beans into standing stubble of previous cereal stubble to protect against rain-splash of soil-borne spores, protect against erosion and reduce attractiveness of the crop to aphids (aphids may vector viruses).
  - » Consideration also needs to be given to previous crops that may host pathogens such as *Sclerotinia, Rhizoctonia* and *Phoma medicaginis*.
  - » *Ascochyta fabae* and *Botrytis fabae* are faba bean specific, whereas *Botrytis cinerea* has a wide host range including lentil and weeds such as *Euphorbia* spp., groundsel and emu-foot.
  - » *Phoma medicaginis* var. *pinodella* can be hosted by lucerne, clover, field pea, lupin and chickpea as well as *Phaseolus* spp.
- History of bean diseases
  - » Previous occurrence of soil-borne diseases (Sclerotinia stem rot, Stem nematode or perhaps even *Pratylenchus* nematodes) constitutes a risk for subsequent faba bean crops for up to 10 years.
  - » At least 500 m (preferably more) distance from previous year's bean crop.
- Weeds
  - » Realise that nearly all weeds host *Sclerotinia* spp.
  - » Some of the viruses affecting faba and broad bean also have wide host ranges. Weeds, particularly perennial legumes, host viruses and their aphid and leafhopper vectors (e.g. *Cucumber mosaic virus,* CMV).
- Herbicide history
  - » Have triazine, 'imi' or sulfonylurea herbicides been applied in the last 12 months?
  - » The development of some diseases is favoured in herbicide-weakened plants.

The presence of these herbicide residues in soil may cause crop damage and thus confusion over in-field disease diagnosis.

9.3.4 Variety selection

A component of risk assessment is to understand what different varietal ratings mean with respect to a given disease and its management. The National Variety Trial (NVT) Disease Rating System was introduced in 2007 to provide growers, agronomists, industry and researchers with a better understanding of varietal differences in field crops including faba beans in response to different disease interactions, and to deliver uniformity in disease descriptions between crops. It provides one tool to

MORE INFORMATION

Ground Cover Supplement: Nationally coordinated effort to tackle ascochyta blight of pulses growers and agronomists to determine the most appropriate variety by matching disease risk in a given location and situation to the available varieties (Table 1).

In practical terms, under average conditions for disease development, no economic yield loss is expected in resistant varieties, and control measures are unlikely to be profitable. Resistance does not mean immunity though:

- Varieties with a disease description of moderately resistant are expected to sustain low to moderate yield loss and control measures are likely to be cost-effective.
- Varieties with a disease description of moderately resistant to moderately susceptible are expected to sustain moderate to high losses and control measures are necessary to ensure a profitable crop.
- Varieties with disease description of moderately susceptible or worse will sustain very high to total yield loss and control measures are essential to produce a harvestable crop.

Note also that pulse varieties are now rated for Ascochyta blight on both foliage and pods/seed because there are differences. This may influence control strategies and timings during podding to preserve seed quality, hence marketability. Table 1 provides a standard method of rating varieties for disease based on one used by faba bean breeders and pathologists worldwide. We encourage growers and agronomists to use this method and its terminology to help reduce confusion. The table only deals with genetic reactions—management does not change the reactions, just the consequences. [3]

Table 1: *Faba bean variety ratings for the common bean diseases in Australia.*

Variety	Ascochyta blight		Chocolate spot	Rust	Cercospora spot	PSbMV Seed staining
	Foliage	Seed				
Ascot VF	R	R	VS	S	S	–
Aquadulce	MS	MS	MS	MS	S	MS
Cairoⓓ	VS	VS	VS	MS	–	–
Dozaⓓ	VS	VS	MS	MR-R	S	–
Farahⓓ	MR-R	MR-R	S	S	S	S
Fiesta VF	MS-MR	MS	S	S	S	S
Fiord	MS	MS	VS	S	S	S
Icarus	VS	VS	MR	MR	–	–
Manafest	VS	VS	MS	MS	–	–
Nuraⓓ	MR-R	MR-R	S	MS	S	VS
PBA Kareemaⓓ	MR-R	MR-R	MS	MS-MR	S	
PBA Ranaⓓ	R	R	MS	MS-MR	S	MR-R
PBA Wardaⓓ	S	S	MS	MR-R	S	–

VS, Very susceptible; S, susceptible; MS, moderately susceptible; MR, moderately resistant; R, resistant
Source: Pulse Australia.

Note revised status of variety PBA Ranaⓓ, PBA Kareemaⓓ and other northern varieties for rust foliar infection after 2011 incidence; also Nuraⓓ for chocolate spot susceptibility under early sown and higher disease pressure situations.

In a season such as 2010, when repeated cycles of infection occurred, even MR varieties can experience yield-reducing levels of disease.

3 Southern/Western Faba and Broad Bean—Best Management Practices Training Course. Module 3—Varieties. 2013. Pulse Breeding Australia.

9.3.5 Seed quality and treatment

Use only seed of high quality (purity, germination and vigour). Source seed from a paddock where diseases, particularly those that affect pods, were not detected. In particular, seed from a crop known to have been heavily affected by Ascochyta blight should not be used.

Treatment of seed with a fungicide dressing is an option, but not essential; it controls seed-borne Ascochyta blight and Botrytis grey mould, and several soil-borne fungal diseases (Table 2).

Do not mix rhizobial inoculant with fungicide seed dressings. Apply the fungicide seed dressing first and then apply the inoculants as a second operation sometime later after the fungicide has dried and immediately prior to seeding.

Table 2: *Seed dressings registered for use with faba beans (but not often used).*

Active ingredient:	**Thiram**	**thiram + thiabendazole**
Example trade name:	**Thiram®**	**P-Pickel® T**
Ascochyta blight	NR	NR
Botrytis grey mould	NR	NR
Damping off	–	R
Fusarium	–	R
Phoma root rot	–	–
Phytopthora root rot	–	–
Pythium diseases	–	R
Jurisdiction	**All states**	**All states**

R, Registered product label claim. NR, not registered for use in this crop. Refer to the current product label for complete 'Direction for Use' prior to application

Prior to the use of any crop protection product, ensure that it is currently registered or that a current permit exists for its use in faba beans.

Registered labels and current permits can be found on the APVMA website www.apvma.gov.au.

9.3.6 On-farm and off-farm hygiene

Control of volunteer faba or broad beans during summer–-autumn and in fallows is vital to avoid carryover of inoculum of chocolate spot, rust and Ascochyta blight pathogens. Some broadleaf weeds are alternative hosts of one or more of the viruses that affect beans, and of *Sclerotinia* species, and should be killed prior to planting and during crop growth.

Pathogens such as *Ascochyta fabae* can be transmitted via infected stubble and soil. Soil and stubble movement may occur by machinery, during windy and/or wet weather, and flooding. Therefore, it is essential that all headers and sowing equipment be thoroughly cleaned to remove grain, soil and stubble before moving from property to property, and if possible in particularly high-risk disease situations, between individual paddocks. The logistics of actually doing this may be difficult when it comes time to harvest; however, growers need to be aware that decisions that they or their contractor make may increase the risk of certain diseases in the future.

Spray rigs, should also be cleaned to reduce the risk of disease transmission particularly if contractors are used.

Floodwaters may transport disease agents. Floods during January 2011 would have moved faba bean stubble infected with *A. fabae,* as well as soil and weeds harbouring the pathogen.

MORE INFORMATION

GRDC Update Paper: Pulse diseases the watch outs for 2016

Paddock inspections should be carried out using clothing suitable to the task and footwear should ideally be disinfected prior to entering a crop. This is an important point for agronomists who may move through several crops in one day.

9.3.7 Regular crop monitoring

The four main diseases where monitoring is necessary are rust (*Uromyces fabae*), chocolate spot (*Botrytis fabae*), cercospora (*Cercospora zonata*) and Ascochyta blight (*Ascochyta fabae).* By following the monitoring process recommended for these diseases, there is the opportunity to assess the impact or presence of other diseases, weeds or plant disorders. To be effective, crop monitoring needs to include a range of locations in the paddock, preferably following a 'V' or 'W' pattern.

Rust

The time to start monitoring for rust in faba beans depends on sowing time and presence of infection on bean stubble from the previous year.

With early sown beans, infection can occur at early emergence when temperature and rainfall conditions are suitable for its spread. Later sown beans may not get infected until spring when temperatures, moisture conditions and humidity are high. [4] The disease can develop very quickly, requiring only six hours of leaf wetness for infection. Rust is not usually a problem every year in southern regions, and often occurs in years with good spring rainfall and mild temperatures. [5]

In early sown beans, monitor for rust from 2–3 weeks after emergence (4–5 weeks from sowing) and protect against early infection when *Cercospora* is also being controlled with foliar fungicide.

Similarly, for beans sown at more regular times, monitoring for rust can start to occur when the beans are being monitored for infection by *Cercospora* and/or *Ascochyta* early (4–5 weeks from sowing).

In all beans, monitoring for rust needs to occur when monitoring for chocolate spot and late Ascochyta blight.

Chocolate spot

Chocolate spot is more likely to occur in bulky crops where there is canopy closure. The critical stage for the first inspection will be just before the commencement of flowering, as temperatures begin to increase, and then regularly through the flowering and seed-filling period. Lesions occur on leaves and flowers first, but can occur on stems and pods. Flower abortion and drop can occur.

Symptoms first appear as small brown spots on leaves and flowers, which then rapidly develop into large, irregular-shaped lesions on leaves and decay of flowers when conditions remain favourable for the disease.

Chocolate spot (caused by *Botrytis fabae*) requires high leaf moisture or humidity (>70%) within the crop canopy and optimal temperatures are 15–28°C. When humidity levels decrease or maximum daily temperature exceed ~28°C, the infection levels decline sharply. In conditions conducive to chocolate spot, follow the recommendations outlined later in this section.

4 Pulse Australia (2016) Faba bean fungicide guide: 2016 season. Australian Pulse Bulletin, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/2016-season-fungicide-guide

5 K Lindbeck (2015) Pulse diseases the watch outs for 2016.GRDC Update Paper, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Pulse-diseases-the-watch-outs-for-2016

More regular crop monitoring and protection may also be required in high-risk situations such as:

- cropping immediately adjacent to last year's crop
- non-optimal paddock selection (e.g. waterlogging)
- high disease pressure experienced last year
- susceptible variety planted
- shortened rotation. [6]

Cercospora

Cercospora monitoring must start 2–3 weeks after emergence, or within 4–6 weeks of sowing. This is particularly important where faba beans have been grown in the paddock in recent years or there have been quite a few beans grown in that paddock over time.

Protective fungicide needs to be applied before or at first signs of cercospora lesions, or within the monitoring timeline, irrespective of symptoms when disease risk is high.

Subsequent monitoring should occur when checking for chocolate spot prior to and during flowering and podding. [7]

Ascochyta blight

The initial symptoms will be lesions on the leaves and stems of young plants. A distinguishing feature is fungal fruiting structures (small black dots) visible within the centre of lesions.

Monitoring should commence 2–3 weeks after emergence, or 10–14 days after a rain event. This is to allow time for disease expression after an infection event, such as transmission from infected seed or rain-splashed inoculum. Infected seedlings may deteriorate quickly and plant-parts above the lesion may break off, making symptoms difficult to detect.

Timing is critical. After the initial inspection, subsequent inspections should occur every 10–14 days after a rain or heavy dew event. During dry periods, inspections can be less frequent. When monitoring, look for signs of lesions on leaves, or if severe, wilting in upper foliage or small areas of dead or dying plants, and if present examine individual affected plants for symptoms of infection. This method will allow more of the crop to be inspected than a plant-by-plant check. [8]

9.3.8 Foliar fungicides

Foliar fungicides (Table 3) are essential for the management of Ascochyta blight in all varieties, and are an important tool for the management of BGM. Varieties with higher levels of Ascochyta blight resistance do not require as many sprays as susceptible varieties. The success of foliar fungicides depends on timeliness of spraying (hence the importance of regular crop monitoring), appropriate fungicide selection, and correct application. Early detection and fungicide application is vital.

6 Pulse Australia (2016) Faba bean fungicide guide: 2016 season. Australian Pulse Bulletin, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/2016-season-fungicide-guide

7 Pulse Australia (2016) Faba bean fungicide guide: 2016 season. Australian Pulse Bulletin, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/2016-season-fungicide-guide

8 Pulse Australia (2016) Faba bean fungicide guide: 2016 season. Australian Pulse Bulletin, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/2016-season-fungicide-guide

Table 3: *Fungicides registered for use.* [9]

Faba Bean Foliar Fungicide	Trade Name example	Chocolate Spot	Rust	Ascochyta	Cercospora	WHP Harvest
Chlorothalonil 720	CC Barrack 720	1.4-2.3 l/ha	1.4-2.3 l/ha	NR	NR	7 days
Mancozeb 750	Dithane SC	1.7–2.2 l/ha	1.7–2.2 l/ha	1.7–2.2 l/ha	1.7–2.2 l/ha	7 days
Carbendazim	Spin Flo	500 ml/ha	NR	NR	NR	28 days
Procymidone 500	Sumislex 500	500 ml/ha	NR	NR	NR	9 days
Copper	Champ 500DF	1.2 kg/ha	1.2 kg/ha	NR	NR	1 day
Metiram	Polyram DF	1.0–2.2 kg/ha	1.0–2.2 kg/ha	1.0–2.2 kg/ha	1.0–2.2 kg/ha	42 days
Tebuconazole	Folicur SC	NR	145 ml/ha Permit	NR	145 ml/ha Permit	21 days
Prothio + Teb	Prosaro	NR	NR	600-750 ml/ha Permit	NR	21 days
Propiconazole	Tilt, Throttle, FMC Prop	NR	NR	Tilt 500 ml/ha Throttle 250 ml/ha FMC Prop 227 ml/ha Permit	NR	14 days

Many Emergency Use Permits have short term expiry dates (e.g. 30/11/2016)

NR = Not Registered (not effective for this disease)

CHECK CURRENT REGISTRATIONS AT: www.apvma.gov.au

Prior to the use of any crop protection product, ensure that it is currently registered or that a current permit exists for its use in faba beans.

Registered labels and current permits can be found on the APVMA website www.apvma.gov.au.

9.4 Fungal disease control

In many regions seasonal conditions in 2016 have been extremely wet, with continuing rain events and waterlogged soils. Decisions about the viability of crops need to be made early rather than later if disease has taken hold in the crop. It may be a better option to abandon crops and prepare for a following crop if diseases are apparent and environmental conditions favour the disease (saturated soils, average daily temperatures >15°C and high humidity). Faba bean crops will shut down as temperatures rise >28°C and the yield potential will be limited if pods aren't filled in the next few weeks.

The crop needs continuing fungicide protection for good pod fill and many paddocks are not accessible by ground sprayers to give adequate spray coverage required.

If an early decision about crop viability is made, extra costs for crop protection are avoided and nutrients will be available for following crops. In northern areas a summer crop may be an option, if herbicide residues are not a problem. [10]

9.4.1 Principles of fungicide use

A fungicide program needs to account for disease risk categories, based on:

- varietal susceptibility or resistance
- source of seed and treatment of seed
- planting proximity to faba and broad bean stubbles from the previous season
- level of inoculum present from crop residue or volunteer plants

9 Pulse Australia (2016) Faba bean fungicide guide: 2016 season. Australian Pulse Bulletin, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/2016-season-fungicide-guide

10 Pulse Australia (2016) Faba bean fungicide guide: 2016 season. Australian Pulse Bulletin, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/2016-season-fungicide-guide

MORE INFORMATION

Pulse Australia: Faba bean fungicide guide 2016 season

- climatic conditions in relation to disease infection

Registration status

The product must be registered or have a permit for the disease and use.

Withholding Period: All products and timings used in the fungicide program must meet Australian withholding periods and export slaughter intervals to satisfy overseas markets.

Fungicide resistance management

The maximum number of sprays of a product must be adhered to, so as to minimise the risk of fungicide resistance developing.

Mode of action

Using products with a range of mode of actions for control of diseases further reduces the chance of fungicide resistance development and improves efficacy. Fungicides are also recommended at times of the disease life cycle where they will be most effective according to their mode of action.

Early harvest

Harvest at maturity to minimise seed infection and potential down grading. Seed damage from Ascochyta blight is usually more severe when crops are harvested late. The moisture content allowable on delivery is 14%. Harvest losses, seed splitting and downgrading in quality can be substantial if faba beans are harvested at <12% moisture.

9.4.2 When to spray

Fungicide sprays will control fungal disease, but when and how often to spray will depend on the varietal resistance, amount of infection, the impending weather conditions and the potential yield of the pulse crop.

Fungal disease control is geared around protection rather than curing. The first fungicide spray must be applied as early as necessary to minimise the spread of the disease. Additional sprays are required if the weather conditions favour the disease.

9.4.3 Principles of spraying

A fungicide spray at the commencement of flowering protects early pod set. Additional protection may be needed in longer growing seasons until the end of flowering. Fungicides last around 2–3 weeks.

Remember all new growth after spraying is unprotected.

In periods of rapid growth and intense rain (50 mm over several days), the protection period will reduce to ~10 days.

The timing of fungicide sprays is critical (Table 4). A spray in advance of a rainy period is most desirable. Despite some fungicide washing off, the disease will be controlled. Delaying until after a rainy period will decrease the effectiveness of the fungicide as the disease will have started to spread. [11]

The need and timing of repeat fungicide sprays depends on:

- the amount of unprotected growth
- rainfall after spraying
- the likelihood of a further extended rainy period

Unprotected crops can lose >50% in yield. In severe cases the crop may drop all its leaves

11 Southern/Western Faba and Broad Bean—Best Management Practices Training Course. Module 3—Varieties. 2013. Pulse Breeding Australia.

Table 4: *Principles of when to spray for fungal disease control in faba bean.*

Disease	Occurrence	When to spray
Ascochyta blight	First appears in cool and wet conditions before flowering	At 6–8 weeks after sowing, during seedling stage. Again during flowering if Ascochyta blight is detected and rain is likely. Again at end of flowering when pods are filling, if Ascochyta blight is detected and rain is likely. Disease is spread by rainfall
Chocolate spot	Develops late winter (15–20°C) in humid (>70% RH) conditions, usually at flowering	During early to mid-flowering as a protective spray. Additional sprays may be necessary through flowering and pod filling if disease progresses
Cercospora leaf spot	On lowest leaves soon after emergence	Shortly after emergence prior to establishment of disease. Approximately 5–7 weeks after sowing
Rust	Later in the season, during warm (20–30°C) humid conditions.	At first sign of disease during flowering or pod filling.

9.5 Registered fungicides

Registered fungicides to use as seed dressings are listed in Table 2. Note that they are not often used in faba bean.

Registered fungicides to use as foliar fungicides are listed in Table 3.

Refer to the current product labels for complete 'Direction for Use' prior to application.

Prior to the use of any crop protection product, ensure that is currently registered or that a current permit exists for its use in faba beans.

Registered labels and current permits can be found on the APVMA (www.apvma.gov.au).

9.6 Summary of a foliar fungicide strategy

Time-lines and fungicide strategies based on the variety and disease being targeted are summarised in Figure 3 and Table 4. See also Figure 4. The strategy used for each disease is based on the resistance or susceptibility status of the variety. Use Table 1 to determine this. Choose a fungicide or a fungicide mixture to handle the targeted diseases (see Tables 3 and 5).

Consider also the disease carryover (Table 6) and cross-infection (Table 7) potential.

Faba beans
Example fungicide regimes
(R=resistant; MR=moderately resistant; MS=moderately susceptible; S=susceptible

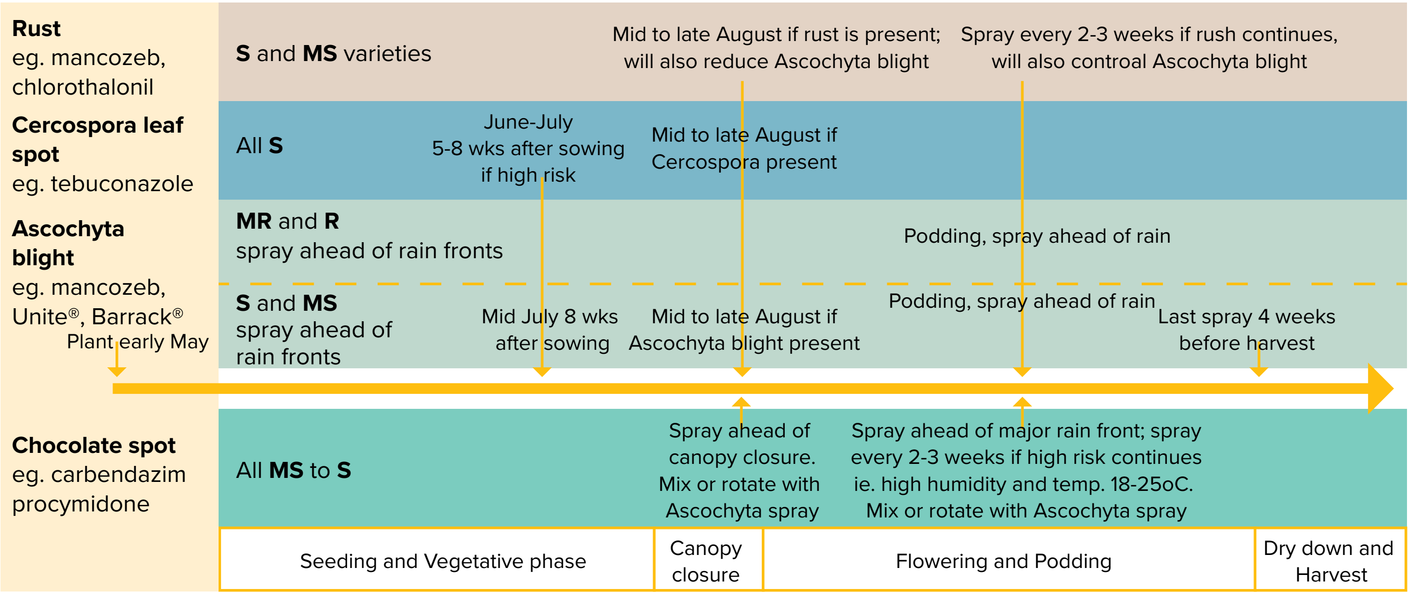


Figure 3: *Fungicide timing for faba bean disease control with specific variety choices. Foliar fungicide application times based on variety resistance (R) or susceptibility (S) to that specific disease (SARDI).*

Source: Jenny Davidson, SARDI

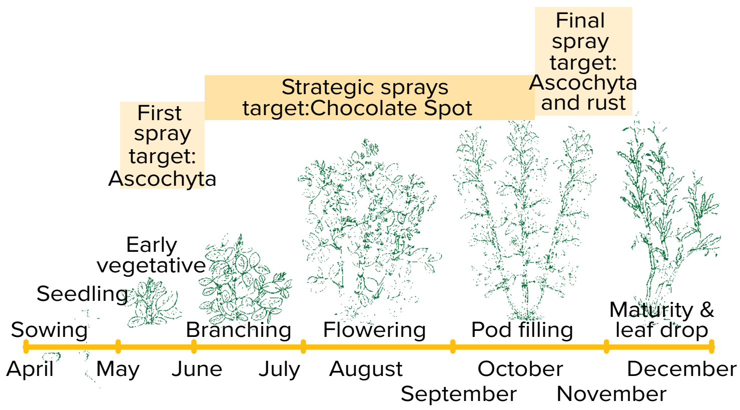


Figure 4: *Crop growth stages and strategic fungicide spray program.*

Source: PulsePoint 16, NSW DPI, 2002

MORE INFORMATION

GRDC Update Paper: Pulse diseases the watch outs for 2016

Table 5: *Fungicide choices.*

Critical period	Disease		Fungicide*	Comments
	Target	Secondary		
First critical period.	Ascochyta blight	–	Mancozeb or chlorothalonil	Early fungicide application is critical to restrict early development and spread of disease.
Early vegetative (5–8 weeks after emergence)	Cercospora leaf spot	–	Tebuconazole or carbendazim	Cercospora spot is often first disease to appear.
	Cercospora leaf spot plus	Chocolate spot	Tebuconazole + mancozeb or use carbendazim	Early chocolate spot control can be important in early sown crops. Rust could be an early target in early sown crops as well. Use the lower rate on crops <20 cm in height.
	Ascochyta blight plus	Cercospora spot	Tebuconazole + Mancozeb or carbendazim + Mancozeb, or chlorothalonil by itself.	Use the higher rate for dense crops or if disease pressure is severe.
	Cercospora leaf spot plus	Ascochyta blight	Either tebuconazole or carbendazim + either Mancozeb or chlorothalonil.	
	Rust plus	Chocolate spot	Mancozeb or chlorothalonil	
Second critical period.	Ascochyta blight plus	Chocolate spot	Mancozeb or chlorothalonil	Early-mid-flowering protection before the disease establishes is recommended: before canopy closure.
Pre canopy closure, during flowering (13–16 weeks after emergence through flowering)	Chocolate spot plus	Ascochyta blight	Either carbendazim or procymidone + either Mancozeb or chlorothalonil	Protection of flowers to assist pod set is important. If Ascochyta blight is detected, and/or chocolate spot appears in the upper third of the crop canopy, and rain or high humidity are likely, then apply fungicide if crop has sufficient yield potential.
	Chocolate spot plus	Cercospora	Carbendazim or chlorothalonil or procymidone + tebuconazole	
	Severe chocolate spot	–	Procymidone	
Third critical period.	Ascochyta blight &/or rust plus	Chocolate spot	Mancozeb or chlorothalonil	If Ascochyta is detected, rain is likely or new spots of chocolate spot appear or are likely to appear on unprotected leaves on the upper third of the plant, then apply or re-apply fungicide if the crop has sufficient yield potential.
Late flowering to end of flowering when pods are filling (15–20 weeks after emergence)	Chocolate spot plus	Ascochyta blight &/or rust	Either carbendazim or procymidone + either Mancozeb or chlorothalonil	Observe all withholding periods.
	Chocolate spot	–	Carbendazim or procymidone	

Note that metiram is considered comparable to mancozeb and so can be substituted for it

Table 6: *Carryover of major faba bean diseases showing their relative importance as sources of infection.*

Disease	Stubble	Seed	Soil
Ascochyta blight	★★★	★★	★
Chocolate spot (*Botrytis*)	★★★	★	★
Cercospora leaf spot	★★	–	★★★
Rust	★	–	–

MORE INFORMATION

Ground Cover Supplement: Close monitoring shows changing pathogen strains

Table 7: *Diseases occurring on pulses with potential for cross-infection.*

	Chickpea	Faba beans	Lentils	Lupins	Peas	Vetch
Botrytis grey mould						
Botrytis cinerea	★★	★★	★★	★	★★	★★
Chocolate spot						
Botrytis fabae	★	★★	★★			★★
Cercospora leaf spot						
Cercospora zonta		★★				
Sclerotinia disease						
Sclerotinia sclerotiorium	★★		★★	★★	★★	
Sclerotinia trifoliorium	★★	★★		★★		
Bacterial blight						
Pseudomonas andropogonis	★					
Pseudomonas syringae pvv. *syringae*		★★	★		★★	
Pseudomonas syringae pvv. *pisi*					★★	
Ascochyta blight						
Ascochyta fabae		★★				★
Ascochyta lentis			★★			
Ascochyta pisi	★				★	★
Ascochyta rabiei	★★					
Phoma blight						
Phoma medicaginis var. *pinodella*	★★	★★	★★	★	★★	★★
Black spot (see also *Phoma* and *Ascochyta*)						
Mycosphaerella pinodes	★★	★	★		★★	★
Anthracnose						
Colletotrichum gloeosporioides				★★		
Brown leaf spot						
Pleiochaeta setosa				★★		
Grey leaf spot						
Stemphylium botryosum	★		★★	★★		

	Chickpea	Faba beans	Lentils	Lupins	Peas	Vetch
Downy mildew						
Peronospora viciae					★★	★
Powdery mildew						
Erysiphe polygoni					★★	
Septoria leaf spot						
Septoria pisi					★★	
Phomopsis disease						
Phomopsis leptostromiformis				★★		
Rust						
Uromyces viciae-fabae[A]		★★			★	★★
Root-lesion nematode						
Pratylenchus neglectus	★					
Pratylenchus thornei	★★	★★				★★
Stem nematode						
Ditylenchus dipsaci	★	★★			★★	★
Viruses						
Bean yellow mosaic virus		★		★★		
Cucumber mosaic virus	★	★	★★	★★		
Luteoviruses complex (e.g. Bean leaf roll virus and Bean western yellows virus)	★★	★★	★		★★	★★
Tomato spotted wilt virus hosted by lupins can cause cross infection in faba beans				★		
Pea seedborne mosaic virus					★★	
Alfalfa mosaic virus	★★	★	★★			★
Wilt						
Fusarium oxysporum[A]				★★	★★	
Root rots						
Fusarium	★	★	★	★	★	★
Macrophomina	★				★★	
Phytophthora medicaginis	★★					
Pleiochaeta setosa			★★			
Pythium [B]	★		★	★	★	
Rhizoctonia	★	★★	★★	★★	★★	★★
Sclerotinia [C]	★		★	★	★	

★ Disease occurs in this crop but does not caused major damage; ★★ Disease has caused major damage to this crop

A Strain differences between crops.

B Pythium and Botrytis grey mould is worse (★★★) in white peas than dun peas (★★)

C Sclerotinia (root rot) is worse (★★) in Kabuli than Desi (★).

9.7 Legal considerations of pesticide use

Before deciding which pesticide to use information should be obtained on the pesticide's registration status, rate of application, withholding period, Occupational health and safety (OH&S) issues, residues and off-target effects. This information is available from the State Department Chemical Standards Branches, chemical resellers, Australian Pesticides and Veterinary Medicines Authority (APVMA) and the pesticide manufacturer.

Background information is provided here to some of the legal issues surrounding fungicide usage, but it by no means exhaustive. Specific questions should be followed up with the relevant staff from your local State Department.

Registration

Users should be aware that all pesticides go through a process called registration, where they are formally authorised (registered) by the Australian Pesticide and Veterinary Medicine Authority (APVMA) for use:

- against specific pests
- at specific rates of product
- in prescribed crops and situations
- where risk assessments have been evaluated and that these uses are:
    - effective against the pest, at that rate, in that crop or situation
    - safe in terms of residues not exceeding the prescribed maximum residue level (MRL)
    - not a trade risk

Labels

A major outcome of the registration process is the approved product label, a legal document, that prescribes the pest and crop situation where a product can be legally used, and how.

Material Safety Data Sheets

Material Safety Data Sheets (MSDS) are also essential reading. These document the hazards posed by the product, and the necessary and legally enforceable handling and storage safety protocols.

Permits

In some cases a product may not be fully registered, but is available under a permit with conditions attached, which often require the generation of further data for eventual registration.

APVMA

The national body in charge of administering these processes is called the Australian Pesticides and Veterinary Medicines Authority (APVMA) and is based in Canberra.

Details of product registrations and permits are available via the APVMA's website www.apvma.gov.au.

Always read the label

Apart from questions about the legality of such an action, the use of products for purposes or in manners not on the label involves potential risks. These risks include reduced efficacy, exceeding MRLs and litigation.

Be aware that pesticide-use guidelines on the label are there to protect product quality and Australian trade by keeping pesticide residues below specified MRLs. Residue limits in any crop are at risk of being exceeded or breached where pesticides:

- are applied at rates higher than the maximum specified

- are applied more frequently than the maximum number of times specified per crop
- are applied within the specified withholding period (i.e. within the shortest time before harvest that a product can be applied)
- are not registered for the crop in question.

9.8 Symptom sorter

Tables 8 and 9 can be used to help diagnose diseases from other crop-damaging causes in faba beans, starting from the symptom description in Table 8.

Table 8: *Faba bean symptom sorter.*

Description	Crop effect	Plant symptoms	Disorder
Scattered plants	Wilting	Premature death	Sclerotinia rot
	Yellow/pale green	Leaves distorted	Mosaic viruses
	Stunted	Premature death	Yellowing viruses
Patches	Poor emergence	Plants chewed	Mouse damage, snails
	Brown/grey	Stem and leaf spotting	Red-legged earth mite, chocolate spot
	Yellow/red	Stunted	Root rots, dodder
		Premature death	Root and crown rot
	Pale green	Leaf and pod spotting	Thrips
	Stunted	Leaves/stem distorted	Stem nematode, mites (seedlings)
	Wilting	Leaves distorted	Cow pea aphids
	Physically damaged	Stems, leaves & pods	Mouse damage, bird/hare damage
Highly alkaline soil	Yellowing	Young leaves yellow	Iron deficiency
		Tip death	Manganese deficiency
	Patches	Plants chewed	Snails
	Stunted	Black leaf edges	Group B herbicide damage
Acidic soil	Yellow/red	Stunted	Nodulation failure
Low lying areas	Grey	Black leaf edges	Frost
	Yellow/red	Premature death	Waterlogging
General	Poor emergence	Stunted	Seed sown too deep
		Tip death	Triazine herbicide
	Stunted	Young leaves yellow	Group F herbicide damage
		Leaf spotting	Zinc deficiency
		Leaves distorted	Clopyralid herbicide damage
	Pale green	Leaves distorted	Group M damage
			Group I herbicide damage
		Leaf spotting	Downy mildew
	Yellow/red	Tip death	Boron toxicity
	Grey/brown	Leaf spotting	Ascochyta blight, chocolate spot, rust, Cercospora leaf spot, Alternaria leaf spot, hail
	Physically damaged	Leaf, stem & pods damaged	Triazine herbicide
	None obvious	Pods chewed	Native budworm
		Pod spotting	Oedema

Source: Faba beans –The Ute Guide (GRDC).

Table 9: *Key features of the main faba bean diseases and disorders.*

Disorder and cause	Seed-borne?	Symptoms	Distribution and occurrence	Survival and spread	Management
Waterlogging or root rotting (root anoxia—not a disease)	No	Slow death; little defoliation; roots not rotted but may be dark; plants hard to pull up	Patches; poorly drained areas; heavy rainfall; higher temperatures, i.e. later in season	Caused by insufficient supply of oxygen to roots	Avoid low lying or poorly drained paddocks or areas within paddocks. Sow in raised beds
Seed-borne root rot *Botrytis cinerea*, *Botrytis fabae* *Ascochyta fabae* (very rare)	Yes	Seedlings wilt and die, epicotyl rots	Rare, as seedling wilting and death is not common to either *Botrytis* or *Ascochyta* in beans. Occurs in random individual plants (not patches)	Seed	Quality seed; seed treatment, variety choice
Chocolate spot *Botrytis fabae* Including: Botrytis grey mould *Botrytis cinerea*	Yes/no	Leaf, flower, stem and pod lesions and rapid tissue death. Possibly lesions covered in mould	Occurs from late winter–early spring when canopy closes and warm humid conditions persist; individual plants but spread quickly to patches	Can be seed-borne, but mostly pathogen has airborne spores which can blow in	Sow a variety with best resistance available. Avoid highly susceptible varieties; use a foliar spray program; plant on wider rows; follow faba bean chocolate spot management package
Sclerotinia root and stem rot *Sclerotinia* spp.	Only as sclerotia in seed	Wilting and death; bleached root, collar and stem tissue; white cottony mould at site of lesion; sclerotia at lesions or inside stems	Root and collar lesions result from direct infection from sclerotia; stem lesions result from air-borne ascospores released from sclerotial apothecia, scattered or patches; favoured by denser canopies, wet events	Sclerotia persist in soil for many years; wide host range including pulses, canola, sunflowers and broadleaf weeds but not cereals or grasses	Sow seed that is clean of sclerotia. Avoid paddocks with history of *Sclerotinia* of its hosts; rotate with cereals; some varieties more susceptible
Rhizoctonia rot *Rhizoctonia solani*	No	Death of seedlings, stunting of survivors due to root damage, re-shooting after damping off of epicotyl	Can be a problem in irrigated crops grown immediately after cotton. Often occurs in 1–5-m stretches of row	Survives in soil and on decomposing trash. Probably present in most soils	Allow time for decomposition of (preceding) crop debris. Tillage should help
Ascochyta blight *Ascochyta fabae*	Yes	Necrotic spotting on all plant parts; lesions with visible fruiting structures (pycnidia); stem lesions; plant death	Individual plants which can spread to small patches, which enlarge rapidly in after rain events to severely damage leaf, stem and pods, possibly killing areas of susceptible crops	Faba bean residue very important in spread especially header dust and surface water flow; infected seed; volunteers	Follow faba bean *Ascochyta* management package, which includes variety choice and foliar fungicides

Disorder and cause	Seed-borne?	Symptoms	Distribution and occurrence	Survival and spread	Management
Cercospora leaf spot *Cercospora zonata*	No	Small dark grey–black lesions on lower leaves early in the season. Change to brown/red as expand and can merge to large lesions. Defoliation in lower canopy at flowering	Scattered plants on infested soil, linked to faba bean history in paddock	Survives in soil and infested faba bean residue	Follow faba bean cercospora leaf spot management package published annually; includes foliar fungicides
Rust *Uromyces viciae-fabae*	No	Leaf, stem and pod pustules develop leading to tissue death	Occurs very early in early sown crops, but normally late in season when warm humid conditions persist; Most plants affected, but possibly in patches. Often in association with chocolate spot	Faba bean residue and self-sown seedlings very important in spread. Airborne spores can blow around	Avoid highly susceptible varieties; use foliar fungicide program; follow faba bean rust–*Ascochyta* management package
Root-lesion nematodes *Pratylenchus* spp	No	Often showing no symptoms. If severe, possibly poor growth; small black lesions on lateral roots sometimes visible	Can affect large areas of crop. *P. thornei* more prevalent on high clay content soils	Wide host range; survives & spreads in soil; anhydrobiosis allows nematodes to persist for prolonged dry periods	Farm hygiene; rotate with resistant species (faba bean is one); grow tolerant varieties
Stem nematode *Ditylenchus dipsaci*	Yes/no	Poor emergence and establishment, stunting and distortion of seedlings, swollen stem bases	Symptoms usually occur in patches, but the large sections of a crop can be affected in severe cases	Wide host range; survives and spreads in soil and plant residue	Farm hygiene; rotate with resistant species
Alfalfa mosaic virus Cucumber mosaic virus	Not in faba beans, but is in other pulses	Not necessarily an issue in faba beans. In other crops is initially bunching, reddening or yellowing, wilting or death of shoot tips; later discoloration	Initially scattered plants or patches, often at edges of crop; more common in thin stands and areas	Viruses persist and multiply in weeds and pasture legumes; aphid-borne	Establish uniform stand by using recommended sowing rates and times; sowing into standing stubble
Phloem-limited viruses (luteoviruses): Bean leaf roll virus Subterranean clover redleaf virus Beet western yellows virus Subterranean clover stunt virus	No	Death of entire plant; luteovirus-infected plants often have discoloured phloem	Close to lucerne, irrigated perennial clovers; seasons or districts with major aphid flights		Cereal stubble deters aphids; avoid sowing too early; grow resistant varieties

9.9 Rust

(*Uromyces viciae-fabae*)

9.9.1 Symptoms

Numerous small, orange–brown pustules, surrounded by a light yellow halo appear on the leaves of plants affected by rust (see Figures 5 and 6). As the disease develops severely infected leaves wither and drop off (Figure 7). The rust pustules on the stems are similar to, but often larger than, those on these leaves. Late in the season, stem lesions darken as resting spores of the fungus are produced in pustules (Figure 8).

Isolated rust pustules may also appear on the pods. A severe rust infection may cause premature defoliation, resulting in smaller seeds.

Figure 5: *Young rust infections have a pale green ring, compared with no ring around chocolate spot infection (at pencil tip).*

Photo: Grain Legume Handbook

Figure 6: *Bean rust shows as orange 'bumps' on leaves.*

Photo: SARDI .

Figure 7: *Leaves can be heavily infected with rust.*

Photo: Grain Legume Handbook

Figure 8: *Rust on faba bean stem.*

Photo: Grain Legume Handbook

9.9.2 Economic impact

Rust is most prevalent in all warmer bean-growing areas, i.e. the northern grains region, and may significantly reduce yields. The disease has caused losses of up to 30% on its own, and in combination with chocolate spot has reduced yields by up to 50%.

9.9.3 Disease cycle

The fungus survives on stubble trash and infects self-sown bean plants directly without the need for alternate hosts. Rust spores are blown long distances onto new crops by the wind.

Rust pustules form on the first few plants to be infected and the disease spreads from these to other plants. Rainfall or dew is necessary for infection.

Rust can occur from early to mid-spring onwards and is favoured by warm temperatures (>20oC). Rust infection can occur following 6 hours of leaf wetness, so does not require extended wet periods.

9.9.4 Control

Growing resistant varieties will reduce the risk of disease infections (see Table 1). Prevention is difficult because the fungus spores can be carried long distances by wind to infect crops far from the initial source of infection.

Risk of the disease can be reduced by burning or burial of old bean stubbles and crop rotation.

Fungicides may be used to control the disease and prevent a rust epidemic (see Table 3 and Table 5) in areas where the disease is most prevalent. Several sprays will be necessary for adequate disease control.

Fungicides for rust: Rust can become an important disease in beans during late flowering and podding. A foliar spray of mancozeb, chlorothalonil or a copper product will control rust.

Mancozeb or chlorothalonil provides the added key benefit of suppressing chocolate spot and Ascochyta blight.

A permit for tebuconazole use in faba beans and broad beans was approved in September 2013.

The permit for tebuconazole has been issued as PER13752 and applies from 31 May 2013 until 30 June 2016. A copy is available from the APVMA website (http://permits.apvma.gov.au/PER13752.PDF). The old permit (PER12657) and the three-day withholding period are no longer current. Significant changes to observe with the new permit include:

- where it is the only active in products containing 430 g/L of tebuconazole;
- long withholding periods (WHPs): 21 days for harvest and 14 days for grazing (adherence to these new WHPs should not be difficult for bean growers);
- approved use for rust and *Cercospora*; and
- a maximum of three applications at 145 mL/ha still applies. [12]

MORE INFORMATION

http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-106-Sept-Oct-2013/New-faba-bean-rust-option

9.10 Chocolate spot

(*Botrytis fabae*)

9.10.1 Symptoms

Spots, ranging from small leaf spots to complete blackening of the entire plant are symptoms of chocolate spot. Leaves are the main areas affected, but under favourable conditions, the disease may also affect stems, flowers and pods (Figures 9–19).

The disease usually occurs in two phases: first a 'passive' (non-aggressive) phase where reddish-brown spots are 'peppered' over the leaves and stem and then an 'aggressive' phase, where tissue around the spots is rapidly killed leaving large, black or grey blighted sections on plant parts.

Small, black sclerotia can sometimes be found inside the stems of badly diseased plants. In moist conditions, the fruiting structures of this fungus may be visible, protruding as grey hair-like formations from the surface of infected plant parts e.g. on the underside of diseased leaves.

12 Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 6—Disease Management. 2013. GRDC/Pulse Australia.

Figure 9: *Poor pod set and leaf loss from failing to protect against chocolate spot early.*

Photo: Pulse Australia

Figure 10: *Chocolate spot can cause thick parts of crop (e.g. headlands) to lodge.*

Photo: Grain Legume Handbook

Figure 11: *Infections of chocolate spot in beans start as small brown spots.*

Photo: Grain Legume Handbook

Figure 12: *Two examples of chocolate spot leaf lesions. (Photos: SARDI).*

Figure 13: *Chocolate spot (*Botrytis fabae*) lesion in the field, showing some expansion across the leaf.*

Photo: Joop Van Leur, NSWDPI

Figure 14: *Chocolate spot (*Botrytis fabae*) lesion from Figure 13 showing lesion expansion and sporulation after a few days in humid chamber.*

Photo: Joop Van Leur, NSWDPI

Figure 15: *Chocolate spot on flowers will prevent pod set.*

Photo: SARDI

Figure 16: *Grey, dead areas of chocolate spot spread and flowers are also blighted, stopping any pod set.*

Photo: Grain Legume Handbook

Figure 17: *Chocolate spot on stems.*

Photo: Grain Legume Handbook

Figure 18: *Chocolate spot on leaves.*

Photo: Grain Legume Handbook

Figure 19: *Chocolate spot lesion on pod leading to infection and staining on seed.*

Photo: SARDI

Figure 20: *Stained faba beans.*

Photo: SARDI

9.10.2 Economic importance

Chocolate spot occurs in all areas where faba beans are grown. It is the major disease of faba beans in southern Australia. Losses range from minor to complete crop failure depending on the seriousness of infection, the time at which infection occurs and the amount of spring rainfall.

In unprotected crops, the disease commonly reduces yields by 30–50% in a bad year, mainly by preventing podset (see Figures 15 and 16)

Seed from badly affected plants may have a reddish-brown stain, which lowers its market value (Figure 20).

Symptoms of chocolate spot can be confused with symptoms of Cercospora leaf spot or damage on leaves from herbicides or physical events, which then allow minor diseases such as *Alternaria* (*Alternaria alternata*) to infect. Correct disease identification is necessary to avoid unnecessary spraying or incorrect fungicide use.

9.10.3 Disease cycle

The fungus can survive in crop debris, in infected seed, or on self-sown plants. Infection usually begins when spores originating from infested bean trash are carried onto new crops by wind. These spores can be carried over long distances. Chocolate spot may also be introduced into new bean-growing districts by sowing infected seed.

Once the disease becomes established it rapidly spreads within the crop. It spreads most aggressively in warm, humid conditions particularly at flowering time.

Chocolate spot is favoured by warm (15–25°C), humid conditions (>70% RH) that extend for 4–5 days and can spread rapidly within a crop. It typically develops later in the season during flowering and after canopy closure. Yield loss due to chocolate spot results from pod abortion and plant damage.

9.10.4 Control

Varieties with resistance to the disease should be grown in areas where the likelihood of chocolate spot is high.

Disease risk can be reduced by destroying all bean trash and self-sown plants before sowing, by sowing disease-free seed and by crop rotation. Delaying sowing also reduces disease risk.

Fungicides can be used to control the disease (see Tables 3 and 5).

Fungicides available for chocolate spot include those containing mancozeb, chlorothalonil, carbendazim or procymidone. Copper products may have some efficacy. Chocolate spot is targeted in critical period 2, as well as critical period 3 (see Table 5).

If chocolate spot incidence is high or the disease is spreading in the crop, then carbendazim or procymidone are more effective than chlorothalonil, mancozeb or copper.

Label regulations limit carbendazim to a maximum of two consecutive sprays at 14-day intervals. Carbendazim is a systemic fungicide with single-site specificity so the probability of resistance developing increases with regular use. It is best to alternate carbendazim with either chlorothalonil or mancozeb. Observe the withholding period for grain prior to harvest for carbendazim (30 days).To ensure that chocolate spot is controlled before it has a significant impact on the yield of the crop, the crop should be checked for disease every seven days while the temperature remains below 15°C. If the weather is mild with day temperatures between 15°C and 20°C and humidity >70%, crop inspections should be made every three days.

Spraying to control chocolate spot could begin at early flowering as a protective spray that is able to penetrate the canopy.Follow up sprays will be necessary where:

- chocolate spot lesions are visible within the upper canopy, or
- relative humidity in the crop is likely to remain high for at least a week, or
- disease is increasing.

9.10.5 Chocolate spot management options

Follow the principles of integrated disease management (IDM) which include:

- crop rotation and paddock selection
- growing resistant varieties (Table 1)
- clean seed and fungicide seed dressings
- canopy management through time of sowing, seeding rate and row spacing
- regular crop monitoring
- strict hygiene on and off farm
- strategic use of foliar fungicides.

Note: Seed dressings (Table 2) are not usually required, and only protect the emerging seedling from seed-borne *Botrytis* and common root rots. Seed dressings will not protect the emerged seedling from raindrop splashed *Ascochyta* or wind-borne botrytis.

Differing spray programs have been developed based on each variety's chocolate spot rating (Figure 3 and Table 6).

Fungicides used in faba beans are predominantly used as protectants only—unlike wheat stripe rust fungicides, most have little or no systemic action, and they will not eradicate an existing infection. Procymidone has some systemic activity, and carbendazim has some limited systemic activity that should not be relied upon. To be effective, all these fungicides must be applied before infection and before it spreads, i.e. before rain. The key to a successful chocolate spot spray program is regular monitoring combined with strategic, timely application of registered fungicides ahead of rainfall events (Figures 3 and 4, Table 3).

Moderately resistant (MR)

(No varieties currently available)

Varieties with some resistance to chocolate spot may require fewer and later fungicide applications for chocolate spot (*Botrytis*) control. The disease simply moves slower in these varieties, but will be devastating if left unprotected in high disease pressure situations.

Moderately susceptible (MS)

(PBA Rana⚙, PBA Kareema⚙, PBA Warda⚙, Aquadulce, Doza⚙)

If the disease is present or the risk is deemed high, apply an early foliar fungicide for chocolate spot, either just before canopy closure or before flowering. Repeat foliar fungicide will likely need to be applied during flowering and podding to ensure leaves are retained clean of lesions. Application at late podding may be required to protect grain quality in high-risk situations or if the disease is present. Note that these varieties will have minimal botrytis in the pods and seeds if the leaf canopy is kept clean of the disease.

Varieties with moderate susceptibility to chocolate spot may require no fewer and just as many fungicide applications for botrytis control as a susceptible variety. The disease does move slower in these varieties, but will be devastating if left unprotected in medium to high disease pressure situations.

Susceptible (S)

(Nura⚙, Farah⚙, Fiesta)

Apply an early foliar fungicide for chocolate spot just before canopy closure or before flowering if the disease is present or the risk is deemed high. Repeat foliar fungicide likely will be required during flowering and podding, until flowering is completed and no more new growth occurs. Ensure leaves are retained clean of lesions so that grain can be filled and to protect grain quality in high risk or disease pressure situations. Note that these varieties will have minimal botrytis in the pods if the leaf canopy is kept clean of the disease.

Very susceptible (VS)

(Fiord, Cairo⚙)

Regular foliar fungicide applications for chocolate spot control will be necessary in most areas, commencing early and applying it before a prolonged rainfall event. Apply a fungicide before the disease is detected, from the commencement of flowering until 4 weeks before maturity. Starting early with protective applications applied ahead of a rainfall event is critical, as control is often ineffective if fungicides are applied after the disease has taken hold. [13]

13 Southern/Western Faba & Broad Bean—Best Management Practices Training Course. Module 6—Disease Management. 2013. GRDC/ Pulse Australia.

9.11 Ascochyta blight

(*Ascochyta fabae*)

9.11.1 Symptoms

Ascochyta blight starts as grey spots. These show through both sides of leaves whereas young chocolate spot lesions do not show through at first (Figure 21). *Ascochyta* spots become irregularly shaped, and they may merge to cover most of the leaf surface (Figure 22).

Leaf tissue next to the affected patches may become black and die off. Many tiny black fruiting bodies develop within the patches as the disease progresses. The pale centres may fall out, leaving holes in leaves (Figures 23 and 24).

Patches on the stem tend to be elongated, sunken and darker than leaf lesions and usually covered with scattered fruiting bodies (Figure 25). The stems may split and break at the point of infection causing plants to lodge (Figure 26).

On pods, the infected patches are black and sunken (Figures 27 and 28). Well-developed patches can penetrate the pod and infect the developing seeds. Infected seeds may be smaller than normal and discoloured (Figure 29). Badly infected pods may split open and seeds can have brown or black stains (Figure 30).

Symptoms of Ascochyta blight may be confused with symptoms of Cercospora leaf spot or damage on leaves from herbicides or physical events, which then allow minor diseases such as *Alternaria* (*Alternaria alternata*) to infect. Correct disease identification is necessary to avoid unnecessary spraying or incorrect fungicide use.

Figure 21: *Infections start as small grey spots and may spread to the leaf edge following moisture run. Inset; Ascochyta lesion.*

Photo: Grain Legume Handbook

Figure 22: *Typical* Ascochyta *blight lesion.*

Photo: SARDI

Figure 23: *Older infections turn pale with black specks.*

Photo: Grain Legume Handbook

Figure 24: *Spotting from herbicide application can look like Ascochyta blight or Cercospora leaf spot, but note absence of pycnidia.*

Photo: SARDI

Figure 25: *Stem infections are sunken with pale centres.*

Photo: Grain Legume Handbook

Figure 26: *Severe stem infections can cause complete blight of stems (on left).*

Photo: Grain Legume Handbook

Figure 27: *Pod infections are black and sunken. They range from small isolated spots to the large multiple infection shown here.*

Photo: Grain Legume Handbook

Figure 28: *Ascochyta blight pod lesions affect seed quality. Protection is required as it is all too late when it gets to this stage.*

Photo: DPI Vic

Figure 29: *Left: Ascochyta blight on bean stems cause stem breakage and lodging. Right: Staining resulting from Ascochyta infection. The disease is transferred by seed to new crop.*

Photo: Grain Legume Handbook

Figure 30: *Bean grain with Ascochyta blight damage.*

Photo: SARDI

9.11.2 Economic importance

The disease is widespread in southern Australia, where yield losses of up to 80% may occur.

Ascochyta blight first caused widespread damage to chickpeas in northern New South Wales (NSW) and southern Queensland in 1998, when extremely wet conditions favoured disease development and spread. The fungus is now considered endemic in chickpeas in all growing regions except central Queensland, but is not yet regarded as a significant threat to faba bean north of central NSW. [14]

Beans discoloured by *Ascochyta* infection may be rejected or discounted.

9.11.3 Disease cycle

The *Ascochyta* fungus can survive on crop debris, self-sown plants and on infected seed. The disease spreads short distances from infected to healthy plants by rain splash spores, during the growing season, or over longer distances via wind early in the season.

Infection can occur at any stage of plant growth following either rain or heavy dew. *Ascochyta* infection is likely to occur in environments with prolonged wet, cool (5–15°C) conditions and usually develops early in the growing season. Damage from stem infection often results in serious crop lodging in susceptible varieties. However, development of this disease can also be important late in the season. Pod infection with Ascochyta blight can cause seed staining and the subsequent downgrading of faba bean grain.

9.11.4 Control

Growing resistant varieties (Table 1) will reduce the risk of severe disease infestations and the staining of seed. Ascochyta blight can be controlled by sowing disease-free seed, by crop rotation, by controlling self-sown beans in rotations and by sowing crops away from infected bean trash.

Chemical seed treatments reduce the risk of introducing disease from infected seed (Table 2).

Fungicide use: If risk of *Ascochyta* blight is high, or it persists and continues to spread in the bean crop, then chlorothalonil is considered more effective than mancozeb. Beware of the grazing withholding period and the export slaughter interval (ESI) restriction with chlorothalonil (63 days). Take note of the withholding period for grain prior to harvest for mancozeb (30 days) and chlorothalonil (14 days).

Ascochyta blight is targeted in all critical periods, particularly in susceptible varieties, when conditions favour disease spread.

Foliar sprays with fungicide (Table 3) are likely to be economic for susceptible varieties. Fungicides should be applied at about 6 weeks to reduce lodging losses from stem infections. Late sprays can reduce seed infection.

9.11.5 *Ascochyta* management options

Follow the principles of IDM, which include:

- crop rotation and paddock selection
- growing resistant varieties (Table 1)
- clean seed and fungicide seed dressings
- regular crop monitoring
- strict hygiene on and off farm
- strategic use of foliar fungicides

---

14 K Moore, M Ryley, G Cumming, L Jenkins (2013) Northern Pulse Bulletin. Chickpea: Ascochyta Blight Management. Pulse Australia, Northern Pulse Bulletin. Chickpea: Ascochyta Blight Management. 2013, Pulse Australia

Note: Seed dressings (Table 2) only protect the emerging seedling from seed-borne *Ascochyta* and seed-borne *Botrytis*. Seed dressings will not protect the emerged seedling from rain-drop splashed *Ascochyta* or wind-borne *Botrytis*.

Differing spray programs have been developed based on each variety's Ascochyta blight rating (Figure 3 and Table 1).

Fungicides used in faba beans are protectants only—unlike wheat stripe rust fungicides, they have no systemic action, and they will not eradicate an existing infection. To be effective they must be applied before infection, i.e. before rain. The key to a successful *Ascochyta* spray program is regular monitoring combined with timely application of registered fungicides (Table 3).

Resistant (R)

(PBA Rana⍉, PBA Kareema⍉, Nura⍉, Farah⍉)

Only consider applying an early foliar fungicide for Ascochyta blight if the disease is present and the risk is high.

A foliar fungicide applied during podding is unlikely to be required to protect grain quality in most situations. Note that these varieties have resistance to Ascochyta blight in the pods.

Varieties with resistance to Ascochyta blight require fewer and later fungicide applications for control, if at all. This may result in the early development of chocolate spot infection, which would have normally been controlled as a result of fungicide application for early Ascochyta blight management in less resistant varieties. Early monitoring and control of Chocolate spot is still critical in *Ascochyta*-resistant varieties.

Susceptible (S)

(Fiesta VF, Aquadulce, PBA Warda⍉, Doza⍉, Cairo⍉)

Foliar fungicide applications for Ascochyta blight control will be necessary in most areas, commencing early. Apply a fungicide before the disease is detected, from early emergence (6–8 weeks) through flowering until 4 weeks before maturity. Starting early with protective applications is critical, as control is often ineffective if fungicides are applied after the disease has taken hold. [15]

9.12 *Sclerotinia* stem rot

(*Sclerotinia trifoliorum* var. *fabae, S. sclerotiorum, S. Minor)*

9.12.1 Symptoms

Plants can be attacked at any stage of growth. In young plants the infection usually begins close to ground level and a slimy-wet rot extends into the stem and down into the roots.

Affected plants are easily pulled from the soil. They usually have a blackened base that is covered with cottony, white fungus growth.

Usually isolated plants rather than patches of plants are affected in crops. Older plants can get the infection on any part of their stems, leaves or pods. Infected plants suddenly wilt and collapse.

Sclerotia (2–5 mm in diameter) form on the surface of infected plants and in the central cavity of the stem. These sclerotia are usually white at first then turn black.

9.12.2 Economic importance

Crop losses in Australia have been small so far. However, the disease poses a potential threat.

---

15 Southern/Western Faba and Broad Bean—Best Management Practices Training Course. Module 3—Varieties. 2013. Pulse Breeding Australia.

9.12.3 Disease cycle

The fungus can survive in the soil for several years. It has a wide host range (including oilseed crops) and may survive on other plants even if beans are not grown.

Sclerotinia may act as either a leaf or a root disease. The foliar form of the disease may be spread by airborne spores. Infection begins when these spores settle on the crop. If conditions are cool and wet, the disease develops rapidly and affected plants soon wilt and die.

While damage to the foliage encourages infection, the fungus can infect uninjured tissue.

Root disease occurs when soil-borne spores directly invade the root tissue. A slimy wet root rot develops and the infected plants suddenly wilt and die.

9.12.4 Control

Crop rotation prevents rapid disease build up, but once established in a crop it is difficult to control. Rotations with other legumes and oilseed crops will not break the disease cycle. Cereal crops are not hosts and so can be used in the rotation.

Lower seeding rates, wider row spacing and good weed control allow a more open crop, which remains drier and is less prone to disease.

9.13 Aphanomyces root rot

(Aphanomyces euteiches)

9.13.1 Symptoms

Chlorosis and wilting of the plant, associated with necrosis in the roots.

9.13.2 Economic importance

This root rot has been observed in recent years in parts of northern NSW. It is unlikely to be a major pathogen of faba beans at the present. However, the expansion of this crop in regions with heavy soils and high rainfall, or irrigated fields, increases the risk of losses.

9.13.3 Disease cycle

The fungus survives in soil and is exacerbated by waterlogging. It can spread from crop to crop in the soil, either via infected plant debris or as resting spores.

In wet soils, this fungus can invade plant roots and cause root rot. Wet conditions also encourage the spread of disease within a field. The reduced root development causes the plants to die when they are stressed.

9.13.4 Control

The disease can be reduced by crop rotation.

It is not known if this strain of the disease can also affect other pulses. A pea-infecting strain is known to occur in Europe.

9.14 Botrytis grey mould (BGM)

(Botrytis cinerea)

9.14.1 Background

Botrytis grey mould (BGM) in faba beans is a minor problem compared with chocolate spot (*Botrytis fabae*).

The control of BGM in faba beans is the same as for chocolate spot.

9.14.2 Economic importance

Botrytis grey mould is a less serious disease of faba and broad beans than is chocolate spot in beans in southern Australia, but the two are sometimes found together in association.

Discoloured seed may be rejected or heavily discounted when offered for sale. If seed infection levels are >5% then it may be worth grading the seed.

Occurrence is worst in wet seasons, particularly when crops develop very dense canopies.

9.14.3 Biology and epidemiology

The life cycle of BGM in faba and broad bean is similar to, but only slightly different than that of chocolate spot.

BGM is a significant pathogen of other pulse crops particularly lentil, chickpea and ornamental plants grown under glasshouse conditions, and fruit including grapes, strawberries and apples. Like with chocolate spot, flowers are especially vulnerable to BGM infection. *B. cinerea* does not infect cereals or grasses.

Botrytis cinerea has been recorded on over 138 genera of plants in 70 families. Legumes and asteraceous plants comprise approximately 20% of these records. As well as being a serious pathogen, *B. cinerea* can infect and invade dying and dead plant tissue. This wide host range and saprophytic capacity means inoculum of *B. cinerea* is rarely limiting. If conditions favour infection and disease development, BGM will occur.

This makes management of BGM different from Ascochyta blight, which is more dependent on inoculum, at least in the early phases of an epidemic.

9.15 Root rots, including Phoma blight and damping off

(Fusarium, Rhizoctonia, Pythium spp. and *Phoma medicaginis* var. *pinodella)*

9.15.1 Symptoms

Root rot is the most common symptom of Phoma blight as plants can be infected on the stem below ground level. Lesions on the stems below soil level are black. Infected plants are stressed.

Seedlings affected by root rot gradually turn black and leaves droop. The plants usually do not collapse completely. The taproot may become quite brittle, except in Pythium root rot when they become soft. When plants are pulled from the ground the lower portion of the root snaps off and remains in the soil. The upper portion of the taproot is dark, shows signs of rotting and may lack lateral roots. Distinct dark brown to black lesions may be visible on the taproot.

The leaves and stems of affected plants usually start turning black.

Older plants dry-off prematurely and are often seen scattered across a field.

In some cases, seeds may rot before they emerge.

9.15.2 Economic importance

Root rot can occasionally be a serious disease especially when soils are wet for prolonged periods.

9.15.3 Disease cycle

All the fungi responsible for root rot are soil dwellers, the most important medium of transmission. They can survive from crop to crop in the soil, either on infected plant debris or as resting spores.

In wet soils these fungi can invade plant roots and cause root rot. Wet conditions also encourage the spread of disease within a field. The reduced root development causes the plants to die when they are stressed.

Spores of the fungus produced on crop residue can be carried onto the new crop by wind. 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 spores of the fungus are carried onto neighbouring plants by wind and rain-splash.

Severe pod infection can result in reduced seed set and infected seed.

9.15.4 Management options

The disease can be reduced by crop rotation. As this disease may also affect other pulses, faba beans should be sown in rotation with another non-legume crop. Although faba beans are deemed reasonably tolerant of waterlogging, they should not be grown in areas subject to severe waterlogging.

Damping off can be controlled using fungicide seed treatment, but this is not common practice with faba beans.

Disease risk can be reduced by planting clean seed to prevent disease build up. Fungicidal seed dressing should control seed-borne infection (Table 2). Their use on faba beans is however not a common practice.

9.16 Viruses

Faba and broad beans are naturally infected by around 50 viruses worldwide, and the number continues to increase. Fortunately only few are of major economic importance in Australia.

Major viruses known to infect faba beans in Australia include:

- Bean leaf roll virus (BLRV)
- Beet western yellow virus (BWYV)
- Soybean dwarf virus (SBDV), syn. Subterranean clover red leaf virus (SCRLV)
- Subterranean clover stunt virus (SCSV)
- Clover yellow vein virus (ClYVV)
- Bean yellow mosaic virus (BYMV)

Less common viruses that occur in Australia are:

- Clover yellow vein virus (ClYVV)
- Alfalfa mosaic virus (AMV)
- Tomato spotted wilt virus (TSWV)
- Broad bean wilt virus (BBWV)
- Cucumber mosaic virus (CMV)

Except for TSWV, which is transmitted by specific thrips species, these viruses need aphid vectors to spread from infected to healthy plants.

Note that we need keep other viruses of faba beans out of Australia. Other viruses of economic importance on faba beans globally but not in Australia include Faba bean necrotic yellows virus and Broad bean mottle virus. Also there are viruses that are important in specific locations within specific countries. These include Broad bean true mosaic virus, Broad bean stain virus, Chickpea chlorotic dwarf virus, Milk vetch dwarf virus, Pea early browning virus and Pea enation mosaic virus.

9.16.1 Virus types

Viruses can be classified by the manner in which they are transmitted by insect vectors.

Persistent transmission means that when an insect vector feeds on an infected plant, the virus has to pass through the body of its vector and lodge in its salivary glands before it can be transmitted to a healthy plant, a process that takes >1 day. Once the insect is infectious, it remains so for the rest of its life. Very few aphid species are vectors of this kind of virus in pulses and they tend to colonise the hosts they transmit the virus to (e.g. faba bean). The pea, cowpea and green peach aphids are important as vectors of persistently transmitted viruses in pulses. Because acquisition and transmission of the virus is relatively slow, insecticides that kill aphids can work in suppressing virus spread. Aphids do not often colonise legumes; however, but they will remain for long enough to transmit luteoviruses.

Non-persistent transmission means that the insect vector can land on a virus infected plant, make a brief probe, acquire the virus on its mouth-parts within seconds and then transmit it immediately when probing on a healthy plant. The aphid loses the virus after it probes a healthy plant one or two times. After this, the insect does not infect further plants until it probes another infected plant. The whole process is so quick that insecticides do not act fast enough to prevent transmission, and can exacerbate the situation by making the aphids hyperactive, flitting from plant to plant. Many aphid species are vectors of this type of virus including ones that do not colonise legumes but just land and probe pulse crops while searching for their preferred hosts (e.g. oat and turnip aphids).

The category luteovirus arises from the Latin luteus (yellow), because of the symptomatic yellowing of the plant that occurs as a result of infection. [16]

Table 10: *Virus categories and general symptoms.*

Virus	Aphid transmission	Seed transmission*	Visual symptom type	Visual symptoms	Virus type (genus)
AMV, Alfalfa mosaic virus	Non-persistent	Yes	Shoot tip	Necrotic or chlorotic local lesions, sometimes mosaics that do not necessarily persist	Alfamovirus
BBWV, Broad bean wilt virus	Non-persistent	No	Mosaic, shoot tip	Vein clearing, mottling and necrosis of shoot apex, plant wilts, mottled, malformed and stunted	Fabavirus
BLRV, Bean leaf roll virus	Persistent	No	Top yellowing	Upward leaf-rolling accompanied by interveinal yellowing of older leaves and flowers abscised	Luteovirus
BWYV, Beet western yellows virus	Persistent	No	Top yellowing	Interveinal yellowing of the older or intermediate leaves. Mild chlorotic spotting, yellowing, thickening and brittleness of older leaves	Luteovirus
BYMV, Bean yellow mosaic virus	Non-persistent	Yes	Mosaic	Transient vein chlorosis followed by obvious green or yellow mosaic. Usually no leaf distortion	Potyvirus
CMV, Cucumber mosaic virus	Non-persistent	Yes	Shoot tip	Mosaics, stunting and possibly some chlorosis	Cucumovirus
ClYVV, Clover yellow vein virus	Non-persistent	No	Shoot tip, mosaic	Mosaics, mottles or streaks, vein yellowing or netting	Potyvirus

16 Southern/Western Faba & Broad Bea— Best Management Practices Training Course. Module 6—Disease Management 2013. GRDC/ Pulse Australia.

Virus	Aphid transmission	Seed transmission*	Visual symptom type	Visual symptoms	Virus type (genus)
PSbMV, Pea seed-borne mosaic	Non-persistent	Yes	Mosaic	Systemic dark and light-green zonal leaf mottle, slight to moderate downward rolling of leaf margins. Distortions of leaf shape associated with mottle patterns. Seed markings	Potyvirus
SCRLV, Subterranean clover red leaf virus	Persistent	No	Top yellowing	Mild yellowing, stunting and reddening	Luteovirus
SCSV, Subterranean clover stunt virus	Persistent	No	Top yellowing	Top yellows, tip yellows or leaf roll. Leaf size reduced, petioles and internodes shortened	Nanavirus
TSWV, Tomato spotted wilt virus	Persistent	No	Shoot tip, mosaic	Necrotic and chlorotic local lesions, mosaic, mottling, leaf shape malformation, vein yellowing, ringspots, line patterns, yellow netting and flower colour-breaking	Tospovirus

Seed transmission in faba beans is minimal for all viruses, and of no epidemiological significance. It is, however, significant in terms of quarantine and keeping foreign virus strains out of Australia

In some seasons, viruses can become a problem in bean crops. Viruses such as Bean leaf roll virus (BLRV), Beet western yellows virus (BWYV) and to some extent Pea seed-borne mosaic (PSbMV) are not seed transmitted, but these become established after aphid-vector activity.

The most important factors that predispose pulse crops to severe virus infection are:

- Infected seed or close proximity to a substantial virus reservoir (e.g. lucerne, summer weeds, field peas for PSbMV).
- High summer–autumn rainfall and the subsequent uncontrolled multiplication of aphids on host plants. Early aphid flights to newly emerged crops can cause early infection and economic loss as infected plants act as a reservoir for further spread of infection within the crop.

9.16.2 Symptoms

Initially diseased plants are scattered, but by the time the crop matures, luteoviruses may have infected nearly the entire crop (Figures 31–49).

Luteoviruses cause yellowing and stiffening of the leaves, and sometimes an upwards rolling of the leaf margins (see Figures 31 to 33 for BLRV) If infection occurs at the seedling stage, the whole plant shows symptoms. If infection occurs later, only the tops of shoots show symptoms ('top yellows'). Infected plants become stunted and die prematurely unless infection occurs after podding.

Tomato spotted wilt virus (TSWV) causes tip necrosis and plant death (see Figures 35 to 39). Economically significant incidences have been found in the northern region, since the introduction of the Western flower thrips, a highly efficient TSWV vector in that region. However, it does not yet appear to be a major problem in the southern region. Note that symptoms of thrips feeding can be confused with TSWV (Figures 40 and 41).

Infections by BYMV causes leaves to turn pale green (Figure 45). Usually, there is a mosaic of dark green patches over the pale green leaves. The leaves develop an uneven surface texture and outline compared with healthy leaves. There is little or no stunting.

Figure 31: *Bean leaf roll virus.*

Photo: Grain Legume Handbook

Figure 32: Bean leaf roll virus.

Photo: Joop Van Leur,NSW DPI

Figure 33: *Bean leaf roll virus. Note bare ground around the plants.*

Photo: Pulse Australia

Figure 34: *Clover yellow vein virus (ClYVV) leaf symptoms and tip necrosis prior to eventual plant death. Symptoms in beans can resemble those of Tomato spotted wilt virus (TSWV) with death of the growing point.*

Photo: SARDI

Figure 35: *Tomato spotted wilt virus (TSWV) stem necrosis and ring spot lesions.*

Photo: Joop Van Leur, NSW DPI

Figure 36: *Close up of Tomato spotted wilt virus (TSWV) ring spot lesions.*

Photo: Joop Van Leur, NSW DPI

Figure 37: *Tomato spotted wilt virus (TSWV) stem and tip necrosis.*

Photo: Joop Van Leur, NSW DPI

Figure 38: *Tomato spotted wilt virus (TSWV) pod necrosis.*

Photo: Joop Van Leur, NSW DPI

Figure 39: Tomato spotted wilt virus (TSWV) stem necrosis and black lesions.

Photo: Joop Van Leur, NSW DPI

Figure 40: *Necrosis of the growing tip can caused by thrips feeding only, not by TSWV.*

Photo: Joop Van Leur, NSW DPI

Figure 41: *Necrosis of the growing tip can caused by thrips feeding only, not by TSWV.*

Photo: Joop Van Leur, NSW DPI

Figure 42: *Stem necrosis can be caused by other causes than TSWV, in this case chocolate spot.*

Photo: Joop Van Leur, NSW DPI

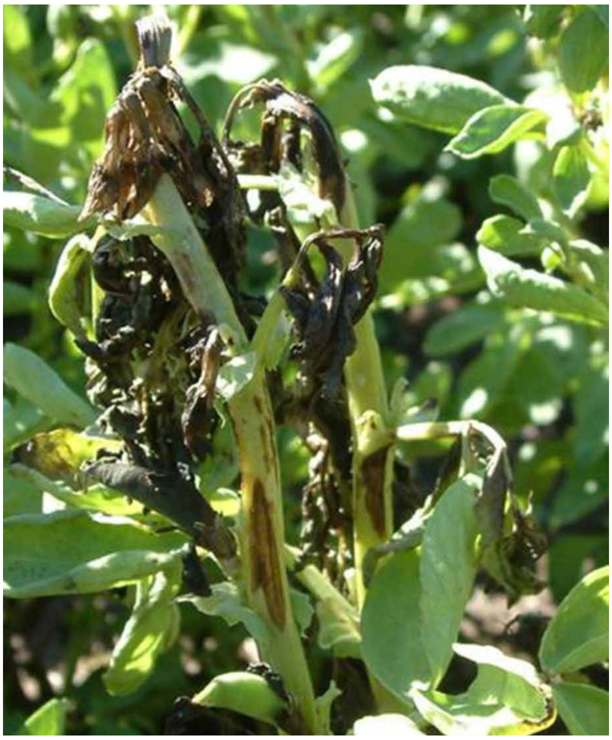


Figure 43: *Stem necrosis can be caused by other causes than TSWV, in this case frost.*

Photo: Joop Van Leur, NSW DPI

Figure 44: *Leaf symptoms of Bean yellow mosaic virus.*

Photo: Grain Legume Handbook

Figure 45: *Bean yellow mosaic virus (BYMV) in faba bean.*

Photo: SARDI

Figure 46: *Pea seed-borne mosaic virus (PSbMV) symptoms in faba bean.*

Photo: Roger Jones, DAFWA

Figure 47: *Bean seed showing Pea seed-borne mosaic virus (PSbMV) marking that can affect marketability.*

Photo: R. Kimber, SARDI

Figure 48: *Subterranean clover stunt virus (SCSV) in very early sown beans.*

Photo: Wayne Hawthorne, Pulse Australia

Figure 49: *Soybean dwarf virus (SBDV) is also known as subterranean clover red leaf virus (SCRLV).*

Photo: Joop Van Leur, NSW DPI

9.16.3 Economic importance

Viruses are a significant problem of faba beans in the northern grain region.

Damage caused by viruses varies greatly from season to season and depends on the prevalence of aphids.

The luteovirus BLRV was detected for the first time in 1993 in northern NSW (in faba beans, narbon beans and a forage legume *Lathyrus ochrus*). By 1995, BLRV had caused major yield losses in faba beans in northern NSW. It had a major impact in parts of South Australia in the drought of 2007.

Another luteovirus, SBDV (also known as SCRLV), has been infecting faba beans crops in Australia since the 1970s and does not appear to be a serious problem.

Bean yellow mosaic virus occurs commonly at a low frequency in faba bean crops and has not caused any serious losses.

Clover yellow vein virus caused plant death in spring-sown beans grown adjacent to irrigated white clover in South Australia in the late1990s. Similar symptoms are seen in faba bean crops on occasions, but can be confused with other causes.

9.16.4 Disease cycle

Aphids bring the viruses into faba bean crops from surrounding plants, usually legumes (e.g. lucerne or clovers). Some viruses, such as BWYV, AMV, CMV, BYMV and TSWV, have a host range that includes non-legume species. Hence other plant species (e.g. sow thistle, turnip weed) can act as a virus source at the start of the season.

9.16.5 Control

There are no totally proven control measures for viruses. Virus management in pulses aims at prevention through integrated management practice that involves controlling the virus source, aphid populations and minimising virus transmission into and within the pulse crop.

Application of seed and foliar insecticides aimed at preventing feeding by aphids can help, but needs further confirmation that they can prevent infection by viruses.

Rotate pulse crops with cereals to reduce virus and vector sources and where possible avoid close proximity to perennial pastures (e.g. lucerne) or other crops that host viruses and aphid vectors. Eliminate summer weeds and self-sown pulses that are a 'green bridge' host for viruses and a refuge for aphids and their multiplication.

Aphids are the major means by which viruses enter faba bean crops. TSWV is, however, spread by thrips. Winged aphids acquire virus by feeding on alternative hosts (particularly lucerne and irrigated perennial clovers) and then land on faba bean plants on which they feed thus transmitting viruses. Probing and feeding needs to be prolonged for transmission of persistently transmitted viruses (0.1–4.0 h for luteoviruses), but brief probing can transmit non-persistently transmitted viruses. Eventually aphids colonise the bean plant and become very visible in the crop.

Cucumber mosaic virus and AMV are non-persistently transmitted by a range of aphid species. *Acyrthosiphon gossypii* is one of many possible vectors of both. The luteoviruses are persistently aphid-transmitted, but are more vector-specific.

Aphids move between adjacent plants to feed before colonising faba beans plants. The result is that faba bean crops show a characteristic scattered distribution of patches of virus-infected plants. This contrasts with crops such as chickpeas, in which aphids do not colonise, where only individual plants are infected.

Aphid activity is influenced by seasonal conditions and will require early monitoring in nearby crops and pastures.

Virus risk can be managed by combining a number of different control measures:

- Suppress the virus source within the crop. Sow seed with <0.1% seed infection.
- Distancing crops from lucerne, weeds or other species that act as a reservoir for viruses, diseasesand aphids.
- Control volunteer weeds during summer and autumn.
- Use a seed treatment of Gaucho 350SD® (imidacloprid), which is registered for early aphid protection to control persistently transmitted viruses.
- Retention of cereal stubble to deter aphids and decrease aphid landing rates.
- Sowing at recommended plant densities to achieve early closure of the crop canopy (closed canopies deter aphids).
- Sowing at recommended times to avoid autumn aphid flights.
- Note that high seeding rates and narrow row spacing to provide early canopy closure assists in aphid control, but conflicts with management of fungal diseases.Ensure faba bean plants are less attractive to aphids by minimising seedling disease, herbicide damage and poor nutrition.

Growers should only consider applying insecticide for virus control if they consider their crops to be at high risk. Insecticides aimed at controlling damage from aphid feeding are normally too late to control virus spread and damage.

Virus testing resources

Several options for diagnostic testing are available. Only some tests can be performed with relative ease in the field.

Note: at least 14 virus species occur in Australian pulse crops (i.e. AMV, BYMV, CMV, BWYV, SCRLV, LNYV, BLRV, TSWV, TSV, TuMV, four mastreviruses).

MORE INFORMATION

http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-86-May-June-2010/Smarter-pest-management

Current testing options may not detect the less common viruses. Detection of virus in one or two plants is not proof that the virus is causing the problem. It is important to check for a range of viruses, as the one being tested for may not be the one or ones causing symptoms.

Detection of a seed-borne virus does not mean there will be virus present in progeny seed. Seed samples from the crop would require testing to determine if seed infection has occurred.

9.17 Root-lesion nematodes (RLN)

(Pratylenchus neglectus, P. Thornei and other *Pratylenchus* spp.*)*

Root-lesion nematodes are discussed at greater length in *GrowNotes Faba Beans 8: Nematode Control.*

Worldwide, the genus *Pratylenchus* is the second most important group of plant-parasitic nematodes. More than 90 species of root lesion nematode (RLN) are known worldwide. The two main species of RLN, *Pratylenchus neglectus* and *P. thornei,* occur in the cropping regions of southern and eastern Australia.

Pratylenchus thornei and *P. neglectus* have been detected at potentially damaging levels in nearly 30% of fields in the northern grain region.

Intolerant wheat varieties can lose >50% yield and some chickpea varieties up to 20% yield when nematode populations are high. [17]

All RLN species cause root damage and yield losses, particularly in cereals. Root lesion nematodes have a wide host range, including cereals and grassy weeds, pulses, pasture and forage legumes and oilseeds.

With the exception of chickpeas, pulses tend to have good resistance to either *P. neglectus* or *P. thornei*, so can reduce nematode populations in cropping rotations.

MORE INFORMATION

Single test improves stubble-borne disease management

Table 11: *Resistence and tolerance of pulses to the major* Pratylenchus *species.*

Crop	*Pratylenchus neglectus*		*Pratylenchus thornei*	
	Resistance	Tolerance	Resistance	Tolerance
Chickpea	S to MR*	MI to T*	VS to R*	MI to T*
Faba bean	MR	–	VS	–
Field pea	R	–	R	T
Lentil	R	T	R	MT
Vetch - Blanchefleur	MR	T	S	I-MI
- Languedoc	MR	T	MS	I-MI
- Morava	MR	T	MS	I-MI

VS, Very susceptible; S, susceptible; MS, moderately susceptible; MR, moderately resistant; R, resistant; I, intolerant; MI, moderately intolerant; T, tolerant; MT, moderately tolerant.

* Chickpea varieties have a range of resistances and tolerances to Pratylenchus species

Repeated glasshouse and field experiments carried out by Department of Agriculture, Fisheries and Forestry Queensland (QDAF) have shown that faba beans are very susceptible to *P. thornei* and moderately resistant to *P. neglectus*. Further trials on the tolerance of faba beans to RLN will be run in 2015–16.

MORE INFORMATION

http://soilquality.org.au/factsheets/root-lesion-nematode-in-queensland/

http://www.daff.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

17 QDAF (2009) Management of root-lesion nematodes in the northern grain region. GRDC/QDAF. http://www.daff.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

What is resistance and tolerance?

Resistance: nematode multiplication

Resistant crops do not allow RLNs to reproduce and increase in number in their roots.

Susceptible crops allow RLN to reproduce so that their numbers increase. Moderately susceptible crops allow increases in nematode populations, but at a slower rate.

Tolerance: crop response

Tolerant varieties/crops yield well when sown in fields containing high populations of nematodes.

Intolerant varieties/crops yield poorly when sown in fields containing high populations of nematodes.

9.17.1 Symptoms

Pratylenchus may impair root function, limiting water and nutrient uptake by the plant. Affected plants may show general un-thriftiness or symptoms of nitrogen deficiency. Symptoms are increased when plants are subjected to water and nutrient stress, or when combined with root damage caused by fungi.

Symptoms of infection on root systems include:

- disintegration of outer layers of root tissue
- reduction in root hairs and/or nodules
- lack of/or stunting of side (lateral) roots
- brown lesions and discoloration of roots.

Root symptoms are often difficult to diagnose in the field and are usually not seen until plants are older than 8 weeks. Root symptoms are generally more obvious in plants grown in sandier soils.

9.17.2 Yield losses

Yield losses to *Pratylenchus* species is an indication of susceptibility. Minimal yield loss however indicates crop tolerance, even though nematode numbers might have multiplied whilst the crop is growing. Resistance is when the nematode population does not multiply during that crop's growth, irrespective of the impact on crop yield.

In trials in 1996, the most tolerant pulse crop varieties, with the least yield losses were Dooen chickpeas, Icarus faba beans and Popany vetch. Amethyst chickpea yield loss due to *Pratylenchus neglectus* was 43%. For *Pratylenchus thornei*, the vetch varieties Blanchefleur and Languedoc appeared intolerant with losses of 27% and 30%.

9.17.3 Symptoms

Severely affected plants are stunted and may have some yellowing of their foliage, but often have no obvious foliar symptoms of disease. Diseased plants usually have shorter lateral roots and fewer root hairs. Microscopic examination of the root system is required to confirm the presence of the nematode.

9.17.4 Economic importance

There is likely to be minimal yield loss in faba beans to *Pratylenchus* nematodes. In susceptible crops like chickpea, yield losses have been up to 50% under heavy nematode numbers. Yield losses in the following wheat crop or pasture may also occur. Nematode numbers appear to increase where susceptible crops like chickpea are grown in rotation with wheat.

9.17.5 Disease cycle

Nematodes are small worm-like organisms <1 mm in length and are able to move freely through moist soils and young root tissues. As the females move through plants they feed on the plant roots, causing lesions, and deposit eggs.

There may be several generations of nematodes within a growing season. Nematodes are likely to multiply under a range of host crops such as wheat and chickpeas. Barley is only moderately susceptible. Many grass weeds and legumes can also host nematodes.

Nematodes survive over the summer months in dry soil and root residues to become active again when the winter rains start.

MORE INFORMATION

Predicta B an identity kit for soil borne pathogens

9.17.6 Management options

Resistant varieties will reduce the impact of nematode infection. *Pratylenchus* can be controlled by using resistant crops such as faba beans, peas or lupins in the rotation. Chickpea–wheat rotations should be avoided where root lesion nematodes numbers are high. Soil-borne disease risk can be assessed through the DNA based Predicta B™ Root Disease Test. [18]

9.18 Improving diagnostic skills

Accurate diagnosis is the first step in successfully managing a problem. The following principles and practical tips will help you reach an accurate answer.

9.18.1 Key diagnostic principles

- Diagnosis draws on several disciplines including plant nutrition, meteorology, soil science, agronomy, entomology, weed science and plant pathology.
- An incorrect diagnosis and inappropriate recommendation will usually be ineffective and possibly more costly than inaction.
- Not all plant disorders are cause by plant pathogens; consider genetic, insect, animal, environmental and agronomic causes.
- Some problems involve more than one cause, although usually there will be only one major cause.
- In some cases, correct diagnosis is impossible without a paddock inspection.
- Take notes (and photographs). As well as recording historical information (e.g. sowing date, variety, previous crop etc.), describing the distribution and symptoms in writing hones observational skill.
- Know what a healthy crop should look like at the major growth stages.

9.18.2 Practical tips

Keep an open mind, and start on a broad scale to establish spatial and temporal patterns.

What is the distribution of the disorder across the district?

Regional distribution of a problem can eliminate many causes and may identify likely ones. If only one crop or one grower in the district has the problem, the cause is unlikely to be environmental, or an air-borne disease, e.g. faba bean rust. Isolated problems often reflect some agronomic problem, e.g. wrong type or rate of herbicide, poor quality seed, inadequate nutrition, nodulation failure, deep seeding or a soil-borne pest or disease.

What is the distribution of the disorder across the paddock?

Is the pattern linked with a farming operation (past and present?), for example:

18 Southern/Western Faba and Broad Bean—Best Management Practices Training Course. Module 3—Varieties 2013. Pulse Breeding Australia.

- Is it linked to cultivation, old fence line, sheep camp, sowing, varieties, spraying, harvesting?
- Does it follow drainage lines or is it confined to low or high parts of the paddock?
- Does it affect individual plants throughout the paddock, individual plants at the edge of the crop or in thin areas, or does it occur in patches?

Walk through the crop with your eyes shut sensing changes in soil compaction to establish links between hard zones and symptoms. Run your hands across the plants. Do they feel stiff and leathery; cool or hot?

What has the weather been like? Could it be frost, heat stress, drought, waterlogging?

What has the insect activity been like? Are there aphids on the windscreen or moths in the crop?

Determine the progression of symptoms. Look at plants showing the range of symptoms from apparently healthy, to just starting to show the problem, to just about the die:

- Are plants easy to pull up?
- Do they break off at ground level?
- Look for evidence of feeding by insects, birds or rodents.

Dig up plants:

- Is soil clinging loosely to their roots (evidence of fungal hyphae)?
- Wash soil from roots in bucket and examine against a light-coloured background.
- Make progressive tangential slices into the root, collar and stem looking for vascular discoloration.

Finally, if you suspect a plant disease, remember the Disease Triangle.

A crop can only have a serious disease problem if three conditions are met:

- susceptible host
- prevalent causal agent
- favourable environment

9.19 Sample preparation for diseased plant specimens

(Compiled information from QDAF Farmnote 115, Don Hutton)

For accurate diagnoses it is imperative that specimens are carefully selected, well presented and submitted with adequate information.

9.19.1 Selection of specimens

Select plants that show the range of symptoms, i.e. slightly to severely affected. Include several healthy plants for comparison. Collect whole plants if practicable, including the roots. For root diseases, include roots and some soil from the root zone (i.e. roots contained in a soil plug).

9.19.2 Preservation

Fresh plant specimens should normally be presented. If delays are likely to occur in transit and plant material is likely to break down and/or become mouldy, dry specimens only should be prepared.

DO NOT FREEZE samples.

Fresh specimens are best stored in aerated conditions at high humidity and cool temperatures (preferably not in the car or ute). Use an Esky with fridge bricks to keep samples cool. Diagnosis of viruses requires very fresh specimens. Plants should be wrapped in dry paper and placed in a plastic bag. The paper should not be wet. If dead tissue is present on the sample, damp paper should be avoided as moulds may develop.

Dried specimens are best when dried rapidly. Place plant parts between sheets of newspaper (with some pressure), and change paper daily for 1 week.

9.19.3 Packaging

Fresh specimens likely to decompose e.g. pods should be wrapped in paper and placed in a suitable container. Other plant parts can be placed in partially inflated plastic bags and tied-off (fairly loosely to allow aeration but not desiccation). Soil samples should be packed in a sealed plastic bag or airtight container.

Dry specimens should be supported between two firm surfaces, e.g. cardboard, before dispatch.

N.B. Diagnoses for suspect virus diseases can only be made with fresh specimens.

9.19.4 Labelling

Use waterproof ink. All containers should be clearly marked. If labels inside bags are used, make sure they are plastic otherwise paper can become mush.

9.19.5 Dispatch

Specimens should be sent ASAP after collection to the relevant authority. If possible, collection and dispatch should be timed to avoid weekend delays in transit and examination. Label the item 'Plant Specimens—Perishable' or 'Soil Samples'.

9.20 References

AJ Biddle, ND Cattlin, JM Kraft (2007). Pests, diseases and disorders of peas and beans. A colour handbook. Manson Publishing, London.

J Davidson *et al.* (2012). Management of pulse diseases in southern Australia: A training handbook for Agronomists, growers and researchers in southern Australia. SARDI.

DPI (2009) Managing viruses in pulse crops. DPI Victoria Agnote Ag1368.

Faba bean: Integrated disease management. Australian Pulse Bulletin, http://www.pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/idm-strategies

A Freeman (2008) Industry Biosecurity Plan for the Grains Industry Threat Specific Contingency Plan. Red Clover Vein Mosaic Virus. Prepared by Dr Angela Freeman and Plant Health Australia July 2008.Descriptions of Plant Viruses (DPV) web site, http://www.dpvweb.net/dpv/dpvnameidx.php

GRDC (2008). Grain Legume Handbook for Pulse Growers. Grain Legume Handbook Committee/GRDC, https://grdc.com.au/uploads/documents/Index.pdf

Managing viruses in pulses. Australian Pulse Bulletin, http://www.pulseaus.com.au/growing-pulses/publications/manage-viruses

NIAB (1990). Diseases of peas and beans. National Institute of Agricultural Botany, Cambridge, UK.

Plant Viruses Online: Descriptions and Lists from the VIDE Database. Version: 20th August 1996, http://sdb.im.ac.cn/vide/refs.htm

Plant Health Australia (2009) Industry Biosecurity Plan for the Grains Industry (Version 2.01) Plant Health Australia, Canberra ACT.

Plant Health Australia (2009) Threat Specific Contingency Plan.

Pulse Seed Treatments & Foliar Fungicides. Pulse Australia Bulletin, http://pulseaus.com.au/storage/app/media/crops/2011_APB-Pulse-seed-treatments-foliar-fungicides.pdf

A Roginski (2012) Disease resistance a faba boon. GRDC Groundcover 101, Nov-Dec 2012, http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-101/Disease-resistance-a-faba-boon

FL Stoddard, AH Nicholas, D Rubiales, J Thomas, AM Villegas-Fernandez(2010). Integrated pest management in faba bean. Field Crops Research, 115:308–318.

P Soleimani, S Hosseini, A Hosseini (2012). Detection of some viral disease of faba bean From Dezful In Iran. Advances in Environmental Biology, 6(2): 662–666.

Virus management in pulses. Pulse Australia Bulletin, http://www.pulseaus.com.au/growing-pulses/publications/manage-viruses