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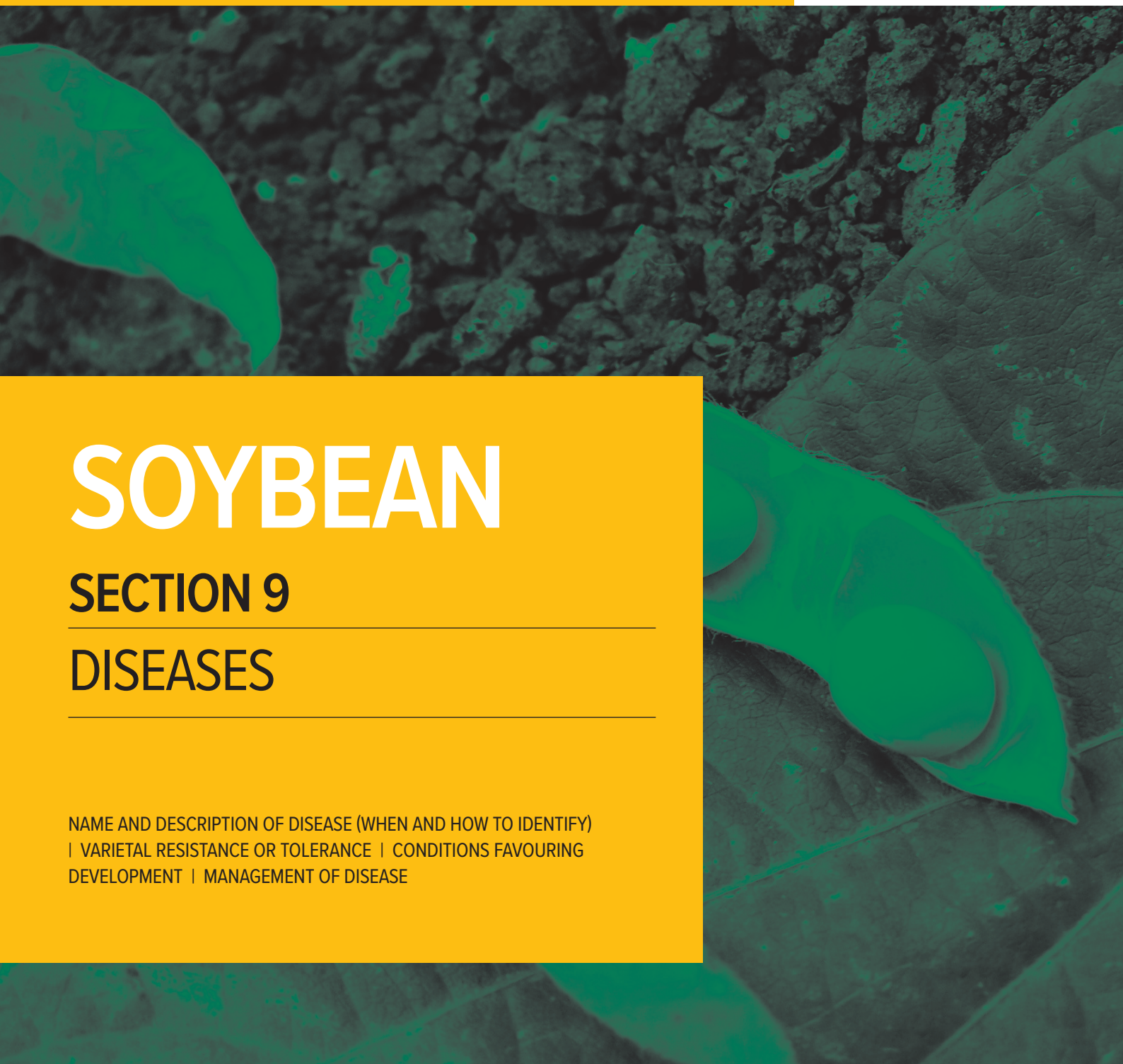

SOYBEAN

SECTION 9

DISEASES

NAME AND DESCRIPTION OF DISEASE (WHEN AND HOW TO IDENTIFY) | VARIETAL RESISTANCE OR TOLERANCE | CONDITIONS FAVOURING DEVELOPMENT | MANAGEMENT OF DISEASE

SECTION 9

Diseases

Soybean crops can be prone to a range of fungal and bacterial diseases. Good crop rotational practices, careful varietal selection and thorough decomposition and incorporation of crop residues will minimise disease occurrences. Avoid planting soybeans after other legumes or sunflowers. [1]

9.1 Name and description of disease (when and how to identify)

9.1.1 Fungal diseases

Soybeans may be affected by the following fungal diseases:

- seedling root rots
- charcoal rot
- Phytophthora root rot
- sclerotinia stem rot
- sclerotium base rot
- pod and stem blight
- Rhizoctonia root rot
- rust
- downy mildew
- purple seed stain
- powdery mildew

9.1.2 Seedling root rots (*Rhizoctonia solani, Phytophthora sojae, and Pythium species*)

Symptoms include seeds rotting in the ground and death of young seedlings after emergence. Young seedlings often display red-brown lesions on the roots and along the lower stem near ground level. Outbreaks of Pythium and Phytophthora are most likely under cold, wet conditions, whereas Rhizoctonia is favoured by rainfall followed by warm weather.

Species of Pythium and Phytophthora survive for a long time as thick-walled oospores. During saturated soil conditions and in the presence of soybean root exudates, oospores germinate to produce sporangia, in which motile (mobile) zoospores develop. The zoospores swim towards the roots, where they encyst and later germinate. The germ tubes then invade the roots, which start to rot. Rhizoctonia survives mainly in infected stubble, so soybeans growing through soybean or other stubble are at high risk.

To minimise losses:

- avoid sowing deeper than 50 mm
- use high-quality seed

[1] Australian Oilseeds Federation, Queensland Soybean Grower Guidelines: http://www.australianoilseeds.com/__data/assets/pdf_file/0010/7669/Queensland_Soybean_Grower_Guidelines.pdf

- minimise the amount of stubble in the vicinity of the sowing line
- use crop rotation

Fungicidal seed dressings containing thiram or metalaxyl may be worth considering. Apply these fungicides to the seed and allow to dry before inoculating with soybean rhizobia. Metalaxyl will control seedling losses only from Phytophthora and Pythium, but infection by Phytophthora is possible later in the growing season.[2]

9.1.3 Charcoal rot (*Macrophomina phaseolina*)

This pathogen can be found in all agricultural soils in Australia. Symptoms usually appear from pod-fill to maturity with affected plants dying prematurely, but seedlings can die when there is hot, dry weather during emergence. Crops under severe moisture or heat stress are particularly susceptible and even irrigated crops can be badly affected. Waterlogging can also predispose plants to infection by *M. phaseolina*.

Leaves on infected plants often wilt and die before any external lesions or discolouration is visible on the stem. However, in most cases the stems of wilted plants turn light tan and later dark brown, and when the bark is peeled away the inner stem will be orange-brown rather than the normal white to light-green colour.

Once the plant has died the external surface of the lower stem and taproot turns a charcoal colour. Internally there is often a grey staining pattern. Affected stems contain minute, black fungal bodies called microsclerotia, which can survive in the soil and crop trash and spread on seed. *M. phaseolina* has a wide host range, including most summer crops and weeds. Evidence suggests that infection of soybean plants occur during the early seedling stages and remain latent until the plants are stressed.

To control the disease, irrigate regularly, rotate soybeans with winter cereal crops and control weeds.[3]

Figure 1: Charcoal rot. (Photo: Australian Oilseeds Federation)

[2] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[3] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

9.1.4 Phytophthora stem and root rot (*Phytophthora sojae*)

Phytophthora root rot is a threat in irrigated systems, especially in southern NSW and northern Victoria. While there are many strains, good resistance to the strains known to be important has been incorporated into the latest varieties.[4]

This pathogen attacks soybean plants at all stages of growth, causing pre-emergence and post-emergence damping off and later wilting and death of older plants.

As *P. sojae* needs free water for spore development, movement and infection, diseased plants will usually occur in patches in poorly drained areas of the paddock and at the tail ditch end of irrigated crops. Infected plants may be later found throughout the field. On older plants the first symptom is wilting and interveinal chlorosis (yellowing) of the lower leaves. However, the diagnostic feature of this disease is a sunken, brown-reddish lesion advancing up the stem, with a distinct margin between the lesion and the green, healthy part of the stem.

Figure 2: Charcoal rot symptoms in the stem. (Photo: Australian Oilseeds Federation)

Infected lateral and branch roots are almost completely destroyed and infested taproots turn dark-brown. Infected plants usually die and withered leaves can remain on the plant for a week or more.

Figure 3: Phytophthora damage. (Photo: Australian Oilseeds Federation)

[4] GRDC (2014) Australian soybeans come of age: http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-113-NovDec-2014/Australian-soybeans-come-of-age

Phytophthora root rot is found throughout all growing regions, and is most severe on heavy, poorly drained soils where soybeans have been grown continuously for several years. As the fungus can survive for many years as thick-walled oospores in soil, avoid planting susceptible varieties where there is a history of the disease in the paddock. The fungus is specific to soybeans and does not occur in other crops or weeds.

Five (5) races (strains, pathotypes) of *P. sojae* have been identified in Australia, with races 1 and 15 being dominant in Queensland and northern NSW and races 4 and 25 dominant in southern Australia. Current varieties have good levels of resistance to the main races – refer to DAF Qld and NSW DPI websites for up-to-date information on varietal resistance.

Another species of Phytophthora, *P. macrochlamydospora* has been found on soybeans only in the coastal growing areas of northern NSW. It causes a root rot without the presence of the typical stem lesion caused by *P. sojae*. Local native legumes are susceptible to the pathogen so it appears that this fungus is indigenous to Australia. The disease generally appears after a crop has been waterlogged or flooded. There is no known resistance to *P. macrochlamydospora*.[5]

9.1.5 Sclerotinia stem rot (*Sclerotinia sclerotiorum*)

Plants infested with sclerotinia develop a white, cottony growth on the stems followed by the formation of large, black sclerotia (resting bodies of the fungus). The infected part of the stem turns soft and white and the plant parts above the lesion dies. Sclerotes may also form in the pith where they are more uniform and cylindrical in shape. The first sign of the disease is dead leaves at the top of individual plants scattered though the crop.

Figure 4: Sclerotinia stem rot showing large black sclerotes (fungal survival structures). (Photo: Australian Oilseeds Federation)

The disease often occurs where soybeans are grown following susceptible crops such as sunflower, navy beans, cotton, peanuts and crucifers. Many broadleaf weeds are also hosts of sclerotinia.

Cool, humid weather conditions, tall, dense crops and overhead spray irrigation during flowering favour the disease. Under these conditions sclerotes germinate to produce a

[5] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

small mushroom-like structure on which spores develop. These airborne spores firstly colonise dead flower petals and leaves and later stems and other aboveground tissues. Regularly inspect the lower canopy of plants after flowering for signs of the disease. No fungicides are currently registered for the control of sclerotinia stem rot.

Avoidance of infested fields and crop rotation are the best management options. Do not grow soybeans in paddocks known to be infested with sclerotinia for at least 4 years after the last affected crop and rotate with grass crops such as sorghum, maize and winter cereals.[6]

9.1.6 Sclerotium base rot (*Sclerotium rolfsii*)

This disease causes wilting and death usually on isolated plants of all ages, but in some situations plant losses can be significant. A brown lesion develops on stems at ground level and a white fan-like mat of fungal strands (mycelium) develops on the lesion and sometimes on the ground and plant residues around the affected stem. Round, brown sclerotia 1-2 mm in diameter usually form in the fungal mat. The disease occurs during hot (25-35°C) weather often after drought conditions and when soil moisture levels are high. Therefore the disease is more common in areas such as central Queensland.

Planting into partly decomposed plant residues increases the risk from infection. The fungus survives as sclerotes or in infected plant residues. Burying infected residue, minimising in-crop machinery movement and rotations with winter cereals will help to minimise the disease.[7]

Figure 5: Sclerotium base rot showing light and dark brown sclerotes and white fungal hyphae. (Photo S. Allen CSD) (Photo: Australian Oilseeds Federation)

9.1.7 Phomopsis pod and stem blight and seed decay (several *Phomopsis*/*Diaporthe* species)

Phomopsis pod and stem blight and seed decay tend to occur more commonly in coastal areas of Queensland and northern New South Wales. Infected plants usually do not display any symptoms of infection until plant death. A slightly sunken brown lesion may develop at the base of a branch or a leaf stalk. After plant death, small black fruiting bodies (pycnidia) develop on stems and pods. On stems, the fruiting bodies tend to develop in rows, whilst on pods the pycnidia are scattered.

Seeds affected by phomopsis are usually discoloured and covered by a white cottony fungal growth. Other symptoms include shrivelling, cracking and splitting of the seed coat. Affected seeds have low vigour and seedlings growing from such seeds usually die.

[6] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[7] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Infected crop residues and seed are the main modes of survival from season to season. Spores, which ooze out of the fruiting bodies, are spread from plant to plant by rain splash. Seed infection occurs during periods of prolonged rainfall during late pod formation. Delaying harvest after wet weather can lead to high infection levels.

Seed decay caused by phomopsis can be minimised by sowing disease free seed, selecting a weathering tolerant variety, timely harvesting and residue management.[8]

Figure 6: Phomopsis stem blight. (Photo: Australian Oilseeds Federation)

9.1.8 Rhizoctinia root rot (*Rhizoctonia solani*)

As well as causing seedling damping off, *R. solani* can also cause root rot in older plants. The first sign of infection is stunted plants, which usually occur in patches across the paddock. There is often a clear boundary between the stunted and healthy plants. The crown and tap roots of affected plants have a reddish brown discoloration, and the lateral roots are short and stubby. Disease outbreaks are favoured by heavy soils and rainfall followed by cool then warm conditions. Rhizoctonia root rot is most common in southern New South Wales and Victorian soybean crops.

The pathogen survives as sclerotia or resting mycelium and also has the ability to saprophytically colonise all types of plant residue. No Australian varieties have resistance to *R. solani*, so rotation out of infested paddocks is the only management option.[9]

9.1.9 Rust (*Phakopsora pachyrhizi*)

Soybean rust is present in most Australian soybean growing regions, and can infect the crop at any stage in its development although it is usually found late in the season. Rust typically occurs on coastal crops with an outbreak occurring every four to five years, but rust has been recorded in inland areas in mild, wet summers. Under ideal conditions pod formation and seed size are affected, often reducing yields by 10% or more.

The disease is favoured by showery weather. Once infected, plants will develop small yellow lesions on the upper-leaf surface. Light red pustules develop on the underside of leaves and release wind-borne spores. Initially, the lesions will usually appear on the

[8] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[9] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

lower leaves, but may later spread rapidly over the entire plant, leading to yellowing and premature defoliation.

In Australia, soybean rust also infects some native glycine species. The pathogen is an obligate parasite and requires a living host for survival, so between cropping seasons it survives on volunteer soybean plants or alternative hosts.

Unfortunately, the current commercial varieties have little resistance to the rust pathogen. Although mancozeb is registered (as various products) for the control of rust, it is a protectant fungicide that is most effective when applied before the disease appears. Several applications should be made, 14 days apart. Overseas, systemic fungicides are applied at the first appearance of the disease. In most years there is little advantage in applying these fungicides during the crop's vegetative stage unless rust levels are high. Early pod formation is the most critical time for systemic fungicide application if rust is present, and a follow-up spray 2 weeks later is recommended. These systemic fungicides are not to be applied after the R5 stage due to residue concerns. Check the APVMA website for fungicides under permit for rust control.[10]

Figure 7: Soybean rust, lower leaf surface (left), upper leaf surface (right). (Photo: Australian Oilseeds Federation).

9.1.10 Downy mildew (*Peronospora manshurica*)

Downy mildew appears on the upper surfaces of young leaves as pale green-light yellow spots expanding to light-dark yellow lesions of varying shape. On the lower leaf surfaces, a white downy growth appears opposite the discoloured lesions and under severe conditions premature leaf drop may occur. While this disease is often widespread during mild, wet seasons, yield loss is insignificant. However, the disease can reduce the quality of the harvested seed due to a white crust (consisting of oospores) on the seed coat. The pathogen survives as oospores in infected leaves and on seed.

The resistance of current varieties is not well known due to the sporadic nature of the disease. New South Wales coastal varieties may be more resistant than other varieties because the disease is more common in this region, but the low incidence and relatively nominal impact of the disease on yield, make this a low priority when selecting varieties.

Do not to retain or use planting seed from downy mildew-infected crops as it can reduce germination and establishment.[11]

[10] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[11] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

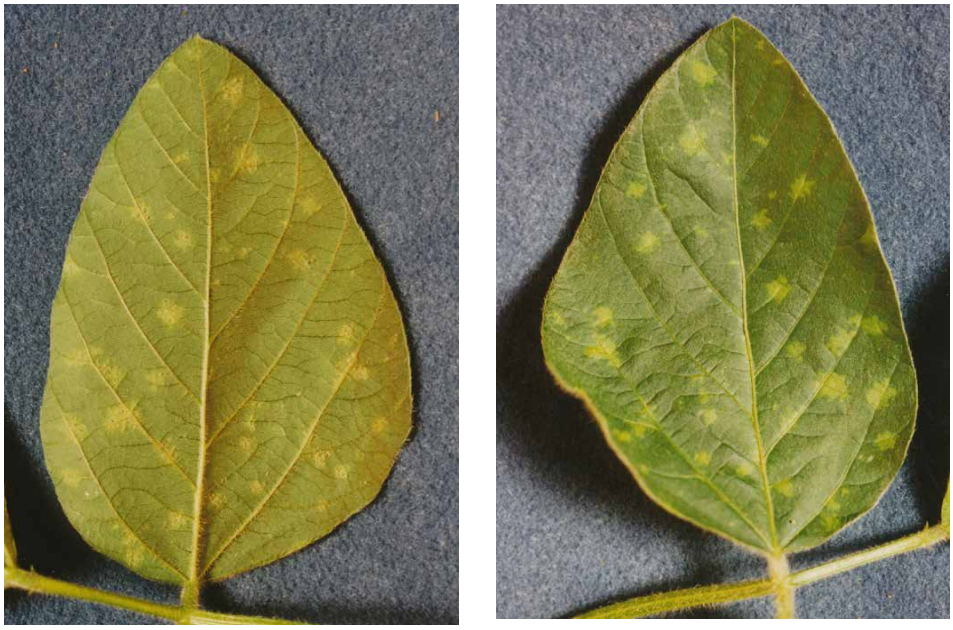

Figure 8: Downy mildew, lower leaf surface (left), upper leaf surface (right). (Photo: Australian Oilseeds Federation)

9.1.11 Purple seed stain (*Cercospora kikuchii*)

Purple seed stain is an occasional and minor problem in most Australian varieties, with the incidence depending on weather conditions during crop growth.[12]

Seeds affected by *C. kikuchii* have a diffuse purple discoloration of the seed coat, which may extend of part or all of the seed coat. This disease is favoured by warm wet weather during which airborne spores developed on infested stubble infect stems, leaves and pods. *C. kikuchii* does not reduce yields, and is not considered detrimental to the quality of beans as the purple colour disappears upon heating. Avoid using infected seed for planting as it can reduce establishment and crop vigour.[13]

Figure 9: Purple seed stain. (Photo: Australian Oilseeds Federation)

[12] M Ryley, Effects of some diseases on the quality of culinary soybean seed: http://www.australianoilseeds.com/__data/assets/file/0004/1201/Malcolm_Ryley-Effects_of_some_diseases_on_the_quality_of_culinary_soybean_seed.pdf

[13] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

9.1.12 Powdery mildew (*Erysiphe diffusa*)

Powdery mildew is a rare disease, although it was found in many crops in southern Queensland and northern New South Wales in the mild and wet 2012 season. White, powdery patches occur on both of the lower leaves, and the disease can later spread onto younger leaves. Spores, which develop on the white powdery growth, spread many kilometres in the wind. The soybean powdery mildew pathogen probably survives from season to season on volunteer soybean plants and perhaps on alternative hosts, but little is known about the host range of this fungus. Based on observations in 2012 significant yield losses can occur under ideal conditions. Evidence suggests that some Australian soybean varieties are more suscpetible to *Erysiphe diffusa* than others.[14]

Figure 10: Powdery mildew. (Photo: Australian Oilseeds Federation)

9.1.13 Bacterial diseases

The pathogens responsible for the major bacterial diseases of soybean do not have other hosts so they survive on un-decomposed crop residues, volunteer soybean plants and infected seed. Once established in a crop, the bacteria can rapidly spread during wet, windy weather. Seed infection can occur during harvesting of a diseased crop. Bacterial diseases include:[15]

- bacterial blight
- bacterial pustule
- wildfire

9.1.14 Bacterial blight (*Pseudomonas syringae pv. glycinea*)

Bacterial blight causes brown, angular spots, which join to form dark-brown, dead areas with yellow margins on the leaves. These areas frequently tear, giving the leaves a ragged appearance. Spots also occur on stems.

While bacterial blight is a common disease in most crops it is never severe (<1% of the leaf affected), causing little or no economic loss. Management strategies involve using high-quality seed, encouraging the breakdown of crop residue and destroying volunteer plants.[16]

[14] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[15] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[16] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Figure 11: Bacterial blight. (Photo: Australian Oilseeds Federation)

9.1.15 Bacterial pustule (*Xanthomonas axonopodis pv. glycines*)

This disease causes small, yellow spots with light-brown centres on leaves. A tan coloured, raised pustule develops at the centre of each spot especially on the lower surface. The raised pustule collapses with age leaving a brown spot with a bright-yellow margin. Pustules also occur on stems.

It is difficult to distinguish this disease from rust when both diseases are at an early stage of development.

While not generally regarded as an important disease, it can be a problem in coastal regions, especially under wetter, more humid seasonal conditions with extended cloud cover. Disease resistance developed through the plant breeding program and field screening is the only practical means of control.[17]

Figure 12: Bacterial pustule. (Photo: Australian Oilseeds Federation)

[17] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

9.1.16 Wildfire (*Pseudomonas syringae pv. tabaci*)

Wildfire is distinguished by brown, dead areas of variable size and shape surrounded by wide, yellow haloes with very distinct margins on plant leaves. The spots may join as the disease progresses. Affected leaves fall readily.

Wildfire generally occurs only after bacterial pustule infection. A bacterial pustule, or a remnant of one, is usually found near the centre of each wildfire spot. Disease resistance developed through the plant breeding program and field screening is the only practical means of control. Wildfire is a rare disease.[18]

9.1.17 Big bud (also called witch's broom and little leaf)

Figure 13: Big bud, also called witch's broom and little leaf. (Photo: Australian Oilseeds Federation)

Phytoplasmas are responsible for this disease, which causes multiple branching, replacement of flower petals with short leafy shoots and small leaflets. Plants affected by phytoplasmas are found at a very low incidence in most soybean crops where they tend to be more common at the edges of crops. Weeds are the main alternative crops and the phytoplasma particles are spread from infected weeds to soybean plants by leafhoppers. The low frequency of phytoplasma infection does not warrant the use of insecticides to manage the insect vectors. Control of weeds around the paddock will reduce the risk of phytoplasma infection.[19]

9.1.18 Viruses

The two main viruses that affect soybeans in Australia are soybean mosaic virus (SMV) and peanut mottle virus (PMV), but neither is economically important. SMV causes a light green-dark green mosaic, vein clearing, rugosity and stunting of leaves, with symptoms are being reduced above 25°C and masked above 30°C. On varieties with seeds that have brown or black hila, infected seeds will display brown or black streaks extending from the hilum. Symptoms of PMV on leaves are similar to those caused by SMV, but line or ring patterns may appear on leaves. PMV is more common when soybean crops are grown near peanuts. The low occurrence and incidence of these

[18] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[19] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

aphid borne viruses means that management through insect control or other practices is not needed.[20]

9.1.19 Nematodes

Root knot nematodes (RKN, caused by *Meliodogyne* species) and root lesion nematodes (RLN, caused by Pratylenchus species) have wide host ranges, on soybeans causing stunting, yellowing, poor growth and wilting during hot, dry weather. The diagnostic feature of root knot nematode infection is the presence of galls or knots of various sizes on the roots of affected plants. Root lesion nematodes cause dark lesions on lateral roots. Root knot nematodes are more severe on light sandy soil, whereas RLNs are more common in heavier soils. Different species of *Meliodogyne* and *Pratylenchus* have different host ranges, so knowledge of the species affecting soybean crops in a particular paddock is needed before effective rotations can be developed.[21]

9.1.20 Sunburn

Sunburn damage results in small, interveinal brick red spots on the underside of leaves but in more severe cases the entire leaf surface may have a diffuse reddish colour. Sometimes the spots develop dead centres and can be colonised by saprophytic fungi and bacteria.[22]

9.2 Varietal resistance or tolerance

Table 1: Variety tolerances [23]

	Colour			Tolerance to				
						Phytophthora[B]		
	Flower	pod hair	hilum	Manganese	Weathering[A] (0–10)	race 1	race15	Sclerotinia[B]
Cowrie	white	grey	clear	++	7	✓	×	unknown
Soya 791	white	grey	buff	0	7	✓	×	+
Zeus	purple	brown	dark	++	10	✓	×	+++
Manta	purple	brown	dark	++	8	✓	×	+++
Poseidon	purple	brown	dark	++	8	✓	✓	+
Surf	purple	grey	clear	unknown	6.5	✓	✓	unknown
A6785	white	grey	buff	unknown	7.5	✓	✓	unknown
Dragon	white	grey	buff	unknown	0	✓	✓	unknown
Warrigal	white	grey	clear	0	2.5	✓	✓	0

9.3 Conditions favouring development

To reduce disease problems, avoid planting soybeans after other legumes or sunflowers. New varieties have genetic resistance to phytophthora, the main disease of soybean.

[20] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[21] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[22] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[23] NSW DPI http://www.australianoilseeds.com/__data/assets/pdf_file/0020/7670/Soybean_North_Coast_NSW_Planting_Guide.pdf

More information

http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Disease-control-in-summer-crops-and-management-strategies-to-minimise-financial-losses

9.4 Management of disease

Integrated disease management (IDM) involves the selection and application of a range of control measures that minimises crop losses, maximises returns and ideally makes minimal impact on the environment, flora and fauna.

Most plants are immune or resistant to almost all plant pathogens. This immunity is normal. However, some pathogens have the ability to infect particular plant species and cause disease. When this occurs, the host is considered susceptible to the pathogen and the pathogen is described as being virulent on that host.

When a virulent pathogen comes into contact with a susceptible host and the environmental conditions are suitable, a disease develops in the host and the characteristic symptoms of that disease are produced.

The disease triangle depicts the interactions between host, pathogen and the environment, the latter having the major impact on the severity of the disease outbreak. Although a pathogen may be present, if the weather conditions are not conducive the disease will not develop on a host.[24]

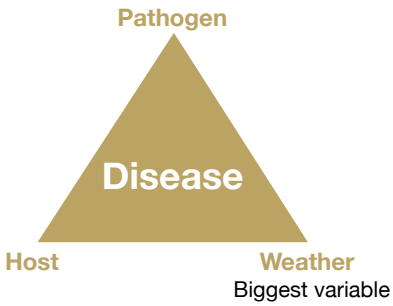

Figure 14: Interaction between host, pathogen and weather determines disease severity.

9.4.1 Integrated Disease Management

Effective Integrated Disease Management (IDM) should be on the whole farm level. Basic strategies should be implemented regardless of whether or not a significant disease exists. Prevention and minimisation of the disease risk is the key to effective IDM.

Best practice strategies

- Staff training: educate staff on possible disease incursions and encourage pro-active feedback on unusual symptoms and plant growth habits.
- Farm hygiene: minimise movement of pathogens between paddocks and between farms. Many pathogens can easily be transferred on tyres, machinery, boots or plant matter such as hay.
- Developing a sound crop rotation strategy: repeated plantings of soybeans will lead to the build up of soil borne pathogens. A good understanding of the host range of major pathogens of soybean is vital.
- Paddock selection: a thorough knowledge of the disease history of paddocks and of the biology of major soybean pathogens will help in paddock selection.
- Management of crop residues and weeds: to minimise carryover and build-up of pathogens, for example nearly all weeds host Sclerotinia.
- High quality seed: use high germination and vigour, disease-free seed to ensure rapid germination and to reduce the risk of seedling diseases. A fungicide seed dressing will also help to minimize risk.

[24] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

- Resistant varieties: use whenever available. Source information on the resistances of varieties to pathogens and select a variety with the highest resistance to the major disease(s) in your area.
- Crop nutrition: a healthy crop is more able to express its resistance/tolerance than a crop under stress.
- Disease awareness: ensure you have up-to-date information on the incidence and biology of current disease outbreaks and whether or not the incidence/severity of outbreaks is increasing each season.
- Regular crop monitoring: regularly check your crops for anything out of the ordinary. Walk through the crop in a W pattern – this will minimise the risk of missing disease hotspots and allow you to gauge any possible edge effects or disease gradients.
- Foliar fungicides: spray registered/permitted fungicides in a timely manner using good application techniques to minimise damage from foliar fungal pathogens.[25]

9.4.2 Risk Assessment

Assessment of disease risk relies on a grower's/adviser's knowledge of paddock history, confidence in forecasts of the weather and possible price, willingness to educate themselves about pathogen biology, and their tolerance for accepting risk.

Some disease management decisions can be made pre-planting.

Other disease management risk factors involve both pre- and post-planting decisions.

Each crop/disease risk analysis will:

Identify the factors that determine risk

- Pathogen: Pathogenicity, survival, transmission and infection mechanism, availability of control measures, is it widespread or sporadic?
- Host: vulnerability, varietal reactions, availability of resistant varieties, host range of major diseases and seed dressings.
- Agronomy: row spacing, soil conditions, cultural practices, plant residues, nutritional interactions, irrigation or dryland, herbicides used, time of planting.
- Weather: weather forecasts including possible temperature variation, rainfall and relative humidity. Climatic conditions affect both plant growth and the pathogen's biological activities. A stressed plant is more vulnerable to disease outbreaks.
- Risk Management: access levels of risk, contemplate ease of implementing management plan, assess cost of implementation, and assess value of possible returns over known risk factors.

Analyse specific known risk factors

- Pathogen: virulence level against varieties, level of inoculums in air/soil/seed, known paddock history, alternative weed hosts for either pathogen or its vector.
- Host: susceptibility to pathogen, stress reactions to herbicides, nutritional disorders.
- Agronomy: weather outlook, time of planting, effectiveness of cultural control methods prior to planting, airborne inoculums levels built up during season.
- Weather: water storage in profile, long term forecast for rain or abnormal conditions, potential for water stress during growing season.
- Risk management: ensure strategy is flexible and adjust as necessary.

[25] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Acknowledge your own acceptable risk level

- Low: crop failure would impact seriously on the farm economic situation, not necessarily a good time to try new and untried cropping options.
- High: a risk of substantial losses if potential returns/financial rewards are high, a failure in the rotation would not unduly affect the potential earning capacity of the farm.

Providing Accurate Diagnosis

Not so easy: diagnosing a plant disorder is not always quick or easy. Unlike insect pests, which are relatively easy to identify, the accurate diagnosis of plant diseases requires patience and at times, a microscope.

Different pathogens can produce similar and confusing symptoms, so the diagnostician needs to keep an open mind until all aspects of the host/pathogen interaction are considered. Several casual agents could be involved in the expression of symptoms.

However, some pathogens cause characteristic symptoms and with experience, a network of other specialists and suitable reference materials, a quick diagnosis can be achieved. There is no substitute for having hands-on approach to soybean disease management – each season will bring its own unique mysteries to solve.

- Be observant: note the range of symptoms you observe in the crop.

Make a list: list all possible culprits as you observe symptoms. Most will be discounted as you progress through your diagnostic analysis.

Study healthy plants: Compare healthy plants with affected plants to understand the effects that a pathogen has had on the plants.

- Check all parts of the plant: symptoms on leaves can be the result of infection by foliar, root or vascular pathogens.
- Are affected plants scattered across the crop, in groups or at the edge of a crop?
- Do the affected plants follow the row or are they randomly distributed across the paddock? Wilted plants along a row can be the result of mechanical damage during cultivation methods. Plants randomly distributed across the paddock are more likely to indicate a soil borne pathogen.
- Are the symptoms widespread across the paddock – if so, are there any abiotic (non-living) reasons why the crop would be uniformly affected. Was a particular herbicide used in the previous rotation that may not have broken down quickly as expected due to weather conditions: was the appropriate rate of fertiliser applied or could the symptoms indicate a nutritional disorder; was a chemical applied off-label or in a mix that caused phytotoxicity; could spray drift be a factor?
- Widespread symptoms can indicate abiotic factors such as
- Soil conditions – deficiencies, toxicities, pH, excess salt in irrigation water
- Adverse climatic conditions – hail, drought, flooding, cold or heatwaves
- Toxic chemical – inappropriate chemical usage, experimental products, growth regulators
- Human error
- Is there a disease gradient into the paddock – if so, has a neighbouring paddock or laneway had a chemical applied that may be phytotoxic to your crop or is a weed growing alongside your crop that may be a host for vector for the disease.
- Pathogens take time to build up in a crop – regular monitoring for both insects, diseases and weed hosts will decrease the chances of unpleasant surprises later in the season.
- Check for distinctive visual or odour symptoms – is there ooze or an unpleasant odour?
- Is the problem restricted to this paddock? Or is it across several varieties? Are the plants at different growth stages? Did the previous crop exhibit any symptoms?

Geographical distribution – some pathogens are more suited to certain growing regions. For example rust is virulent particularly on coastal soybeans and legumes.

Know your pathogens – understanding the life cycles of the pathogens can help with obtaining an accurate diagnosis.

- Check watering schedules – herbicides can accumulate in tail ditches of paddocks – is there a gradient of symptoms up from the end of the paddock? Could these plants be waterlogged? Water logging can lead to nutritional disorders and increase plant susceptibility to disease.
- Symptom variability – can lead to improper diagnosis. Environmental conditions, varietal differences and multiple pathogens infecting the one plant can cause symptom variability. Inspect a number of plants and note common irregularities. If in doubt, get a second opinion.
- Check soil compaction – compacted soil and plough pans will often lead to "right angle root syndrome". Roots are unable to penetrate through the impacted layers resulting in poor root development, which can lead to water stress, nutritional disorders and herbicide damage.

Ask questions – the more information you can gather about a site and affected crop, the better – crop rotational history, variety, herbicide, insecticide and fungicide applications for both this crop and the previous crops, fertiliser applications, chemical applications in nearby crops.

Be aware – many disease outbreaks occur in tandem with outbreaks in other cropping areas. Be aware of changes in environmental conditions, which could lead to potential disease outbreaks.

Ask for help – do not hesitate to contact other specialists. Working together will enhance the chances of an accurate diagnosis and will also improve your knowledge of potential diseases.[26]

9.4.3 Tools of the trade

Reference materials: even specialists who work with plant diseases on a daily basis need reference material. Important reference materials include the GRDC Mungbean and Soybean Disorders: The UteGuide, Compendium of Soybean Diseases 4th edition (APS Press), and the internet.

Hand lens, magnifiers: essential when looking for fruiting bodies in lesions; small digital magnifiers such as Dinolite® are very useful.

Knife or secateurs: invaluable for checking damage to the interior of roots and stems.

Camera: record a range of symptoms and send to a specialist. Sometimes, a few good images is enough for the diagnostician to make a tentative diagnosis.

Paper and plastic bags: place samples in a plastic bag and keep them cool until lab testing can be completed. If the sample has to be posted, ensure overnight delivery or the sample may rot in a plastic bag. If in doubt, use both plastic and paper bags. Send plants displaying a range of symptoms and also include one or two healthy plants.

Esky and cooler bricks: preferably, carry an esky and cooler bricks to keep samples cool before they are sent to a specialist.

GPS: provides an accurate location for data, monitoring outbreaks and disease spread.

Felt pens: ideal for labelling plastic and/or paper bags.

More information

Australian Oilseed Federation, Queensland Grower Guidelines

DAFF Disease

NSW DPI Soybean: Norther Coast Planting Guide

NSW Summer crop production guide 2014

GRDC Soybean Leaf Rust Fact Sheet

Crop Focus, Glyphosate and Fungicide Application Timing in Soybean

[26] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Clipboard and sample information sheets: use a clipboard or notebook to record all the information so it can be recalled and reviewed at a later date if required. An example of a disease information sheet is provided at the end of this module.[27]

[27] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production