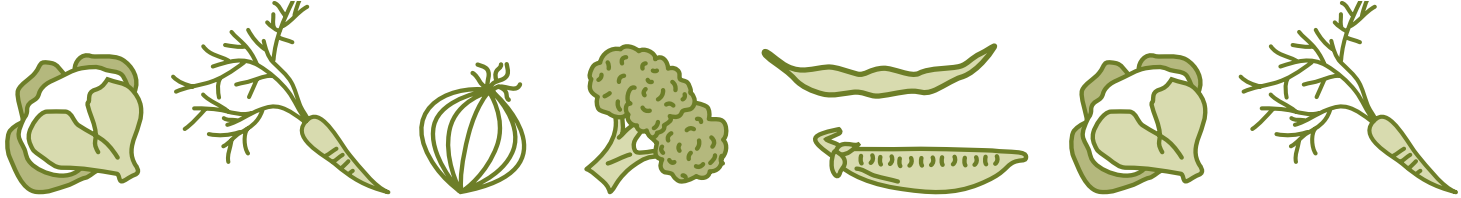
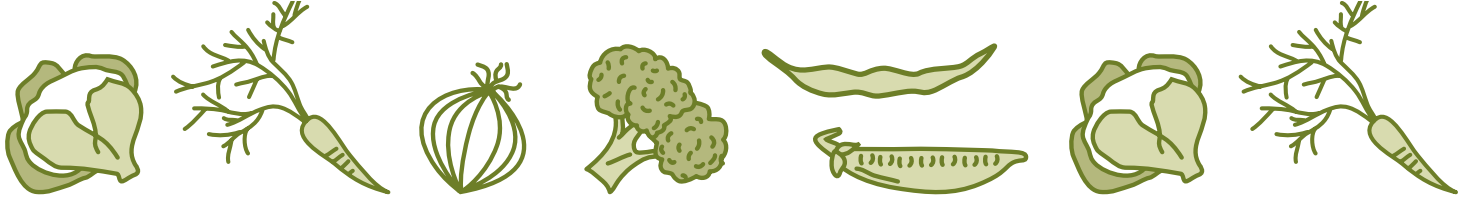
APPENDIX

Contents



Appendix A - Insecticide groups

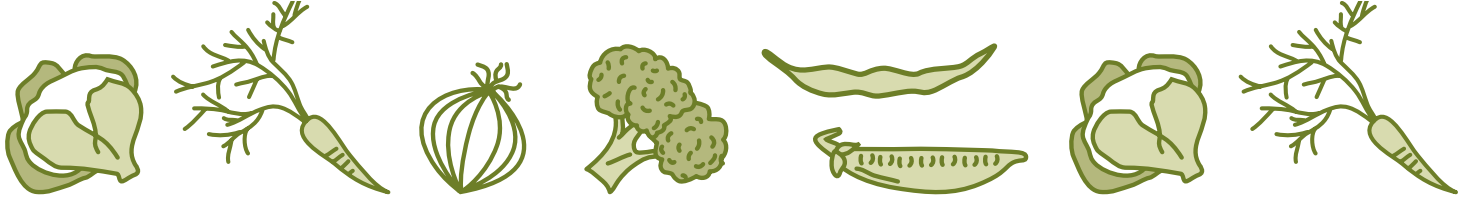
Group	Mode of Action	Chemical Group	Active Constituent	Trade Name
1A	Acetylcholine esterase inhibitors Inhibition of the enzyme acetylcholinesterase, interrupting the transmission of nerve impulses.	Carbamates	Aldicarb	Temik®
			Carbaryl	Carbaryl® Bugmaster®
			Carbosulfan	Marshal®
			Methomyl	Lannate® Nudrin® Marlin® Methomex®
			Methiocarb	Mesurol®
			Oxamyl	Vydate L®
			Pirimicarb	Aphidex® Pirimor®
			Propoxur	Blattanex®
			Thiodicarb	Larvin®
1B	Acetylcholine esterase inhibitors Inhibition of the enzyme acetylcholinesterase, interrupting the transmission of nerve impulses.	Organophosphates	Acephate	Othene Xtra®
			Azamethiphos	Alfacron®
			Azinphos-methyl	Gusathion®
			Cadusafos	Rugby®
			Chlorfenvinphos	Birlane®
			Chlorpyrifos	Lorsban® Chlorfos®
			Coumaphos	Asuntol®
			Dementon-s-methyl	Metasystox®
			Diazinon	Gesapon®
			Dichlorvos	Dichlorvos®
			Dimethoate	Rogor® Sabateur®
			Disulfoton	Disulfton®
			Ethion	Mustang®
			Fenitrothion	Sumithion®
			Fenthion	Lebaycid
			Maldison/malathion	HyMal® Maldison® Monitor®
			Methanidophos	Nitofol®
			Methidathion	Suprathion® Supracide®
			Mevinphos	Phosdrin®
			Omethoate	Le-mat®
			Parathion-methyl	Folidol®
			Phorate	Thimet® Umet®
			Phosmet	Imidan®
			Prothiofos	Tokuthion®
			Profenofos	Curacron®
			Temephos	Abate®
			Terbufos	Counter®
			Trichlorfon	Dipterex®



Group	Mode of Action	Chemical Group	Active Constituent	Trade Name
2A	GABA-gated chloride channel antagonists Interferes with GABA receptors of insect neurons, leading to repetitive nervous discharges.	Cyclodienes	Endosulfan	Endosan®
2B		Polychloro-cycloalthanes	Dicofol	Kelthane®
2C		Phenylpyrazoles	Fipronil	Regent®
3A	Sodium channel modulators Acts as an axonic poison by interfering with the sodium channels of both the peripheral and central nervous system stimulating repetitive nervous discharges leading to paralysis.	Pyrethroids	Allethrin	Roach Tox®
			Alpha-cypermethrin	Fastac® Dominex®
			Beta-cyfluthrin	Bulldock®
			Bifenthrin	Talstar®
			Cyfluthrin	Tugon®
			Cypermethrin	Scud® Sonic® Ploytrin® Cyperkill®
			Deltamethrin	Decis® Clout®
			Esfenvalerate	Hallmark® Sumi Aplha®
			Lambda-cyhalothrin	Karate®
			Permethrin	Ambush® Zeeper® Permasect®
			Resmethrin	Reslin®
			Tau-fluvalinate	Mavrik®
			Tetramethrin	Raid®
4A	Acetycholine receptor agonists/antagonists Binds the nicotinic acetycholine receptor, disrupting nerve transmission.	Chloronicotinyls (Nitorguanidines)	Imidacloprid	Confidor®
4B			Nicotine	
4C			Cartap Bensultap	
5A	Acetylcholine receptor modulators Induces acetylcholine like activity.	Spinosyns	Spinosad	Success® Tracer®
6A	Chloride channel activators Interferes with the GABA nerve receptor of insects	Avermectin	Abamectin	Agrimec®
			Emamectin benzoate	Proclaim®
6B		Milbemycin	Milbemycin	Interceptor®
7A	Juvenile hormone Mimics (IGR's) Mimic juvenile hormones which prevent moulting from the larval to the adult stage	Juvenile hormone analogues	Methoprene	Grain-Star®
			Hydroprene	Raid Maxkill®
7B			Fenoxycarb	Insegar® Genus®
7C			Pyriproxifen	Sumilarv®
8A	Fumigants Unknown or non specific target site	Fumigants	Methyl bromide	Methyl Bromide®
8B			Phosphine®	Fostoxin®
9A	Selective feeding blockers/disrupters	Feeding Blockers/ disrupters	Pymetrozine	Chess®
9B			Cryolite	

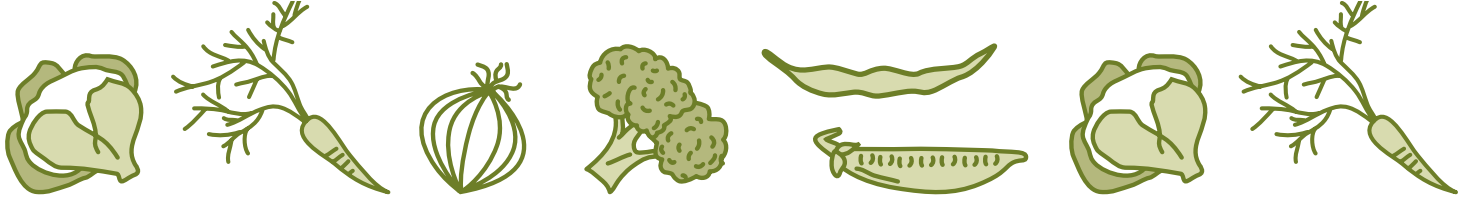
Group	Mode of Action	Chemical Group	Active Constituent	Trade Name
10A	Mite growth inhibitors	Mite growth inhibitors (Ovicides)	Clofentezine	Apollo®
			Hexythiazox	Calibre®
			Tebufenpyrad	Pyranica®
11A	Microbial disrupters of insect midgut membranes Organism has protein inclusions that are released in the gut of the target pest resulting in gut paralysis and a cessation of feeding.	Bt microbial (Biological insecticide/larvicide – Dipteran specific)	Bt tenebrionis	
11B			Bt israelensis	Vectobac®
11C			Bt Kurstaki	Dipel® MVP ® Delfin® Agree®
			Bt aizawai	Xentari®
11D			Bt sphaericus	
11E			Bt tolworthi	
12A	Inhibition of oxidative phosphorylation, disrupters of ATP formation	Organotin miticides	Fenbutanin oxide	Torque®
12B			Diafenthiuron	Pegasus®
13A	Uncoupler of oxidative phosphorylation via disruption of H proton gradient	Pyrrole compound (broad spectrum contact and stomach poison)	Chlorfenapyr	Intrepid® Secure®
14A	Inhibition of magnesium stimulated ATPase	Sulfite ester miticide	Propargite	Comite®
15A	Chitin biosysthesis inhibitors	Acyl ureas	Triflumuron	Zapp®
			Diflubenzuron	Fleececare®
16A	Ecdysone agonists Disrupts insect moulting by antagonizing the insect hormone ecdysone	Benzoic acid hydrazide	Tebufenozide	Mimic®
17A	Inhibit chitin bioysnthesis Type 1 - Homopteran	Thiadiazine	Buprofezin	Applaud®
18A	Inhibit chitin bioysnthesis Type 2 - Dipteran	Triazine	Cyromazine	Vetrazin®
19A	Octopaminergic agonist	Triazapentadiene	Amitraz	Taktic®
20A	Site II electron transport inhibitors		Hydramethylnon	Amdro®
21A	Site 1 electron transport inhibitors	Botanical	Rotenone	Derris®
22A	Voltage dependent	Oxadiazine	Indoxacarb	Avatar® Steward®

Source: Ag NSW - Avcare and Global Crop Protection Federation



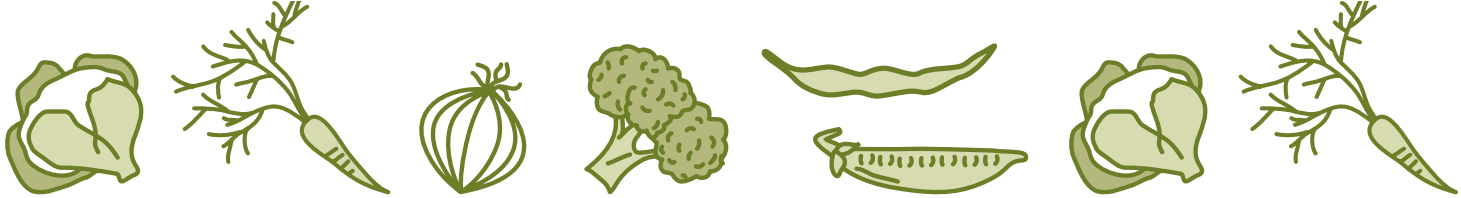
Appendix B - Fungicide groups

Group	Activity Group & Activity	Chemical Group	Active Constituent	Trade Name
A	Benzimadazole Systemic fungicides with protective and curative action. Absorbed by leaves and roots. Translocated in an upward direction. Control a wide range of diseases of fruit, nuts, vegetables, mushrooms, field crops, ornamentals, turf and trees.	Benzimadazole	Benomyl	Benlate®
			Carbendazim	Various
			Thiabendazole	Tecto®
			Thiophanate- methyl	Topsin M®
B	Dicarboximide Contact fungicide with protective and curative action. Inhibits germination of spores and growth of fungal mycelium. Used mainly to control Botrytis, Monilinia and Sclerotinia species.	Dicarboximide	Iprodione	Rovral®
			Procymidone	Sumisclex®
C	DMI Ergosterol biosynthesis inhibitors Systemic fungicides with protective and curative action. Inhibit ergosterol biosynthesis. Translocated in an upward direction.	Imidazole	Imazalil	Fungaflor®
			Prochloraz	Various
		Piperazine	Triforine	Saprol®
		Pyrimidine	Fenarimol	Rubigan®
		Triazole	Bitertanol	Baycor®
			Cyproconazole	Alto®
			Cyproconazole (+ chlorothalonil)	Bravo Plus®
			Cyproconazole (+ iodocarb)	Garrison®
			Diclobutrazole	Vigil®
			Difenoconazole	Score®
			Flusilazole	Various
			Flutriafol	Vincit®
			Hexaconazole	Anvil®
			Myclobutanil	Systhane®
			Paclobutrazol	Cultar®
			Penconazole	Topas®
			Propiconazole	Tilt®
			Tebuconazole	Raxil®
			Triadimefon	Bayleton®
			Triadimenol	Bayfidan
			Triticonazole	Premis®



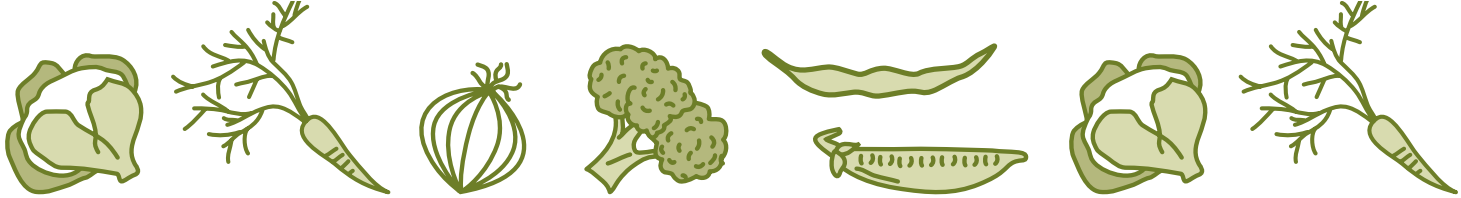
Group	Activity Group & Activity	Chemical Group	Active Constituent	Trade Name
D	Phenylamide Systemic fungicides with protective and curative action. Absorbed by roots, stems and leaves. Translocated in an upward direction. Control pythium and phytopthora root rots and downy mildews.	Acylamine	Benalaxyl (+ mancozeb)	Galben M®
			Furalaxyl	Fongarid®
			Metalaxyl	Ridomil®
			Metalaxyl (+ copper oxychloride)	Ridomil Plus®
			Metalaxyl (+mancozeb)	Ridomil MZ ®
			Metalaxyl – m	Ridomil Gold®
			Metalaxyl – m (+ mancozeb)	Ridomil Gold MZ®
		Cx azolidinene	Oxadixyl (+ mancozeb)	Recoil®
			Oxadixyl (+ probineb)	Fruvit®
E	Morpholine Systemic fungicides with protective and curative action	Morpholine	Tridemorph	Calixin®
F	Posphorothiolate Specific fungicide for powdery mildew control in curcubits.	Organi - phosphorous	Pyrazophos	Afugan®
G	Oxathiin Systemic fungicide. Used as seed treatment to control smuts and bunts of cereal. Systemic fungicide with curative action. Controls rust diseases, fairy rings on turf.	Anilide Carboxin	Oxycarbozin	Vitavax® Plantvax®
H	Hydroxy - pyrimidine	Pyrimidinol	Bupirimate Dimethirimol	Nimrod® Milcurb®
I	Anilino- pyrimidine	Anilino- pyrimidine	Cyprodinil Pyrimethanil	Chorus® Scala®
J	Hydroxyanilide	Hydroxyanilide	Fenhexamid	Teldor®
K	Strobilurin	Strobilurin	Azoxystrobin	Amistar®
			Kresoxim- methyl	Stroby®
			Trifloxystrobin	Flint®
L	Phenylpyrroles	Phenylpyrroles	Fludioxinil	Maxim®

Group	Activity Group & Activity	Chemical Group	Active Constituent	Trade Name
Y	Multi-site activity Systemic fungicide with protective action. Absorbed by roots and transported in an upward direction. Systemic fungicide with protective and curative action. Rapidly absorbed, predominantly through the leaves but also through the roots, with translocation up and down the plant.	Carbamate	Iodocarb Propamocarb	Previcur®
		Phosphonate	Fosetyl-Al Phosphorous acid	Aliette® Various
		Inorganic	Copper (cuprous oxide) Copper (hydroxide) Copper (oxychloride) Iodine Mercury Sodium Metabisulphite Sulphur	Various Various Various Ultra Dyne® Shirtan® Uras Quality® Grapesguard® Various®
		Dithio-carbamate	Mancozeb Metiram Thiram Propineb Zineb Zineb(+copper oxychloride) Ziram	Various® Polygram® Various® Antracol® Various® Copper, Curit® Various
		Phthalimide	Chlorothalonil	Bravo®
		Chlorophenyl	Quintozene	Terrachlor®
		Quinone	Dithianon	Delan®
		Hydroxy-quinoline	8-hydroxy quinoline sulphate	Chinosol®
		Pyradinamine	Fluazinam	Shirlan®
		Cyclic imide	Captan	Captan®
X	Unspecified	Cinnamic acid derivative	Dimethomorph (+mancozeb)	Acrobat MZ®
		Sulfamide	Dichlofuanid	Euparen®
			Tolyfluanid	Euparen Multi®
		Dinitrophenyl	Dinocap	Karathane®
		Organo-phosphate	Tolclofos-methyl	Rizolex®
		Guanidine	Dodine	Various
			Guazatine	Panoctine®
		Thiadiazole	Etridiazole	Terrazole®
		Quinoxaline	Oxythioquinox	Morestan®
			Pencycuron	Monceren®



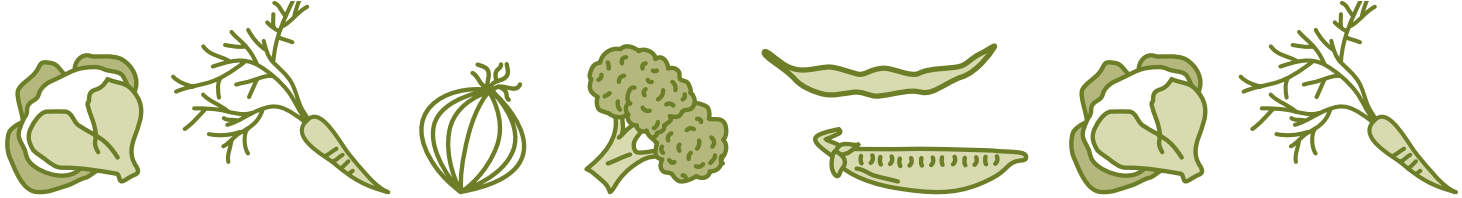
Appendix C - Herbicide groups

Group	Mode of Action Group	Chemical Group	Active Constituent	Trade Name
A	Inhibitors of acetyl coA carboxylase	Arylaxphenaxy propionates ('Fops')	Diclofop-methyl	Hoegrass®
			Fluazifop- butyl	Fusliade®
			Haloxyfop-ethoxy-ethyl	Verdict®
			Quizalofop-p-ethyl	Targa®
			Fenoxaprop-ethyl	Puma®
			Propaquizafop	Correct®
		Cyclohexa-nediones ('Dims')	Sethoxydim	Sertin®
			Tralkoxydim	Achieve®
			Clethodim	Select®
			Butroxydim	Falcon®
B	Inhibitors of acetolactate synthase Inhibitors of cell division and growth	Sulfonylureas	Chlorsulfuron	Glean®
			Sulfosulfuron	Monza®
			Rimsulfuron	Titus®
			Metsulfuron-methyl	Ally®
			Triasulfuron	Logran®
			Bensulfuron-methyl	Londax®
			Thifensulfuron-methyl	Harmony®
			Sulfometuron-methyl	Oust®
		Imidazolinones	Imazethapyr	Spinnaker®
			Imazapyr	Arsenal®
			Imazapic	Flame®
		Sulfonamides	Flumetsulam	Broadstrike®
			Metosulam	Eclipse®



Group	Mode of Action Group	Chemical Group	Active Constituent	Trade Name
C	Inhibitors of photosynthesis at photosystemII	Triazines	Ametryn	Various
			Atrazine	Various
			Simazine	Gesatop®
			Cyanazine	Bladex®
			Terbutryn	Igran®
			Prometryn	Gesagard®
		Triazinones	Metribuzin	Various
			Hexazinone	Velpar®
		Ureas	Diuron	various
			Linuron	Afalon®
			Metoxuron	Carrotex®
			Siduron	Tupersan®
			Ethidimuron	Ustilan®
			Methabenzthiazuron	Tribunil®
			Fluometuron	Cotoran®
			Tebuthiuron	Graslan®
			Methazole	Probe®
		Nitriles	Bromoxynil	Various
			Ioxynil	Totril®
		Benzothiadiazoles	Bentazone	Basagran®
		Acetamides	Propanil	Ronacil®
		Uracils	Bromacil	Hyvar x®
			Terbacil	Sinbar®
		Pyridazinone	Chloridazon	Pyramin®
		Phenyl-pyridazine	Pyridate	Tough®
D	Inhibitors of tubulin information	Dinitroanilines	Trifluralin	Treflan®
			Oryzalin	Surflan®
			Pendimethalin	Stomp®
		Benzoic acid	Chlorthal	Dacthal®
		Pyridines	Thiazopyr	Visor®
E	Inhibitors of mitosis	Carbamate	Chlorpropham	Various
		Thiocarbamates	Tri-allate	Avadex BW®
			EPTC	Eptam®
			Vernolate	Vernam®
			Molinate	Ordram®
			Pebulate	Tillam®
			Thiobencarb	Saturn®
		Organophosphorus	Bensulide	various
F	Inhibitors of caretenoid biosynthesis	Nicotinanilides	Diflufenican	Brodal®
		Triazole	Amitrole	Various
		Pyridazinone	Norflurazon	Solicam®
		Pyrazoles	Benzofenap	Taipan®
		Isoxazolidinones	Clomazone	Command®
G	Inhibitors of protoporphyrinogen oxidase	Diphenyl ethers	Acifluorfen	Blazer®
			Oxyfluorfen	Goal®
		Oxadiazole	Oxadiazon	Ronstar®

Group	Mode of Action Group	Chemical Group	Active Constituent	Trade Name
H	Inhibitors of protein synthesis	Thiocarbamate	Thiobencarb	Saturn®
I	Disrupters of plant cell growth	Phenoxys	2,4-D	Various
			2,4-DB	Various
			MCPA	Various
			MCPB	Tropotox®
			Dichlorprop	Various
			Mecoprop	Various
		Benzoic acids	Dicamba	Banvel®
		Pyridines	Picloram	Tordon®
			Clopyralid	Lontrel®
			Fluroxypyr	Starane®
			Triclopyr	Garlon®
J	Inhibitors of fat synthesis	Alkanoic acids	Dalapon (2,2-DPA)	Various
			TCA	Fenocil II®
K	Herbicides with diverse sites of action	Amides	Diphenamid	Enide®
			Metolachlor	Dual®
			Propachlor	Ramrod®
			Propyzamide	Kerb®
			Napropamide	Devrinol®
		Organoarsenic	MSMA	Daconate®
		Carbamates	Asulam	Asulox®
			Phenmedipham	Betanal®
		Amino propionaes	Flamprop-methyl	Mataven®
		Benzofurans	Ethofumesate	Tramat®
		Phthalamate	Naptalam	Alanap®
		Nitrile	Dichlobenil	various
L	Inhibitors of photosynthesis at photosystem 1	Bipyridyls	Paraquat	Gramoxone®
			Diquat	Reglone®
M	Inhibitors of EPSP synthase	Glycines	Glyphosate	Roundup®
			Glyphosate - trimesium	Touchdown®
N	Inhibitors of glutamine synthetase	Glycines	Glufosinate-ammonium	



Appendix D - Diseases in detail

Anthracnose

Scientific name

Colleototrichum lindemuthianum

Host

All edible beans

Damage symptoms

Small, dark spots or lesions will first appear on young seedlings. As the plant grows, the spotty lesions will eventually infect the stems, leaves and pods. The lesions gradually develop into larger, circular, sunken lesions on the plant. Black streaking along both sides of the leaf vein is also a common symptom. In moist conditions, small, salmon coloured spores may develop in the centre of the lesion.

Life cycle

Hot, humid and moist conditions favour this fungus. The salmon pink masses that appear are masses of spores called conidia. The conidia are released when wet and are generally spread via water droplets, wind and movement of contaminated soil or machinery. The spores can survive on infected plant debris for up to 2 years, although the majority of the disease spreads through infected seed.

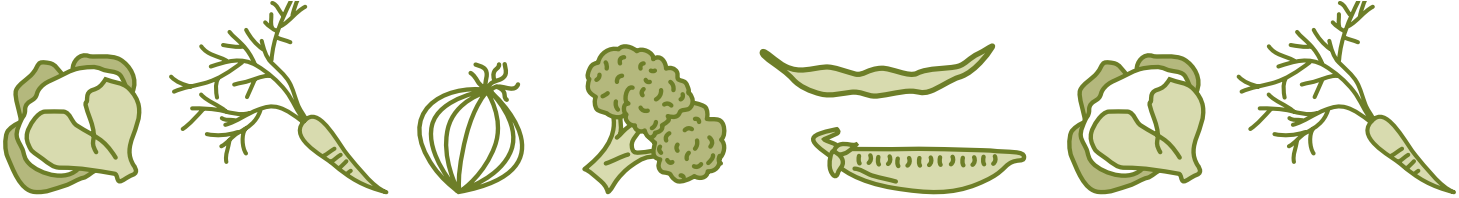
Management 0ptions

Cultural/Mechanical

- Use pathogen free seed and/or resistant varieties if available.
- Remove infected plants.
- Avoid cultivation and harvesting in damp/wet conditions as this can aid the spread of spores.
- Don't harvest and pack diseased pods.
- Use a minimum three year crop rotation. This will starve the pathogen of its host.

Chemical

- Treat seeds with a recommended fungicide prior to planting.



Ascochyta

Scientific name

Phoma exigua ; syn. *Ascochyta phaseolorum* (range of species)

Host

Beans, peas, brassicas, potatoes

Damage symptoms

Causes collar, leaf, stem and pod rots of green peas. Symptoms appear on both the pods and the leaves of the host plant. The leaves will show distinct circular, grey-brown spots with a brown margin surrounding the infection spots. The spots range from about 5-25 mm in diameter. The spots eventually dry out leaving holes in the leaf. In some cases, small, black, fruiting bodies called pycnidia can be visible in the centre of the lesion. Pods may have distinct large, blackened spots around the infection site. The pod may dry out or rot and fall off.

Life cycle

The diseases can occur every year, but tend to be worse in early crops when cool and moist conditions favour growth and spread of the fungi. The small, dark, fruiting bodies (pycnidia) hold a large number of spores which are released when splashed with water. The spores are spread via water, wind and movement of infected soil on machinery. The spores enter and initiate infection on the host plant via open lesions on pods and leaves. Root and stem rot is often seed-borne. The disease can survive in crop debris and in the soil for 3-4 years.

Management options

Cultural

- Crop rotation is important in reducing Ascochyta, and a rotation of 3 to 4 years should be used.
- Remove/destroy crop residue immediately after harvest.
- Disease most often seed borne so use certified seed.

Chemical

- Seed treatments are available.

Bacterial brown spot

Scientific Name

Pseudomonas syringae

Host

Beans, brassicas

Damage symptoms

Symptoms appear on the leaves and pods. Small, light-brown, circular spots with a red-brown margin first appear on the plant leaves. A distinct yellow halo may surround the entire spot. The leaf veins may bind the spots, in which case the spots may appear to be irregular rather than circular. Symptoms on the pod are initially dark green, circular and water soaked. The lesions will change to light brown, enlarge and become sunken. The lesions may cause the pod to bend or become twisted.

Life cycle

The bacterium initially infects the plant via wounds which may have been caused by mechanical damage to the plant or by other fungal infections. It flourishes in wet and cool conditions and is easily spread by wind, rain, irrigation and the movement of machinery. The bacterium over-winters in crop residue and other host plants.

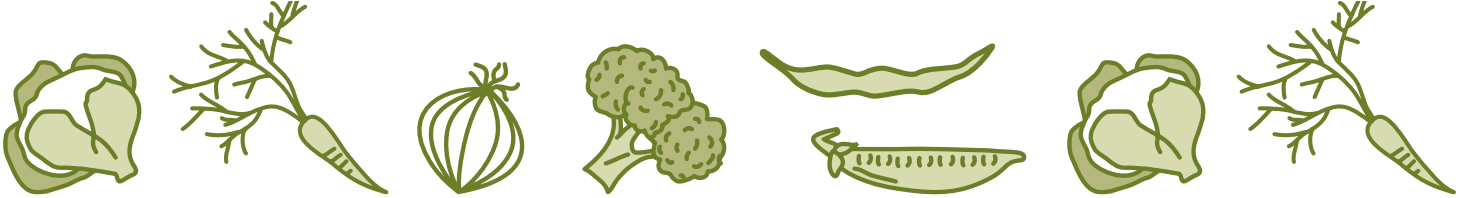
Management options

Cultural

- Use disease free, certified seed.
- Remove crop residue after harvesting.
- Minimise the movement of machinery through infected areas in wet conditions.

Chemical

- Registered copper sprays may prevent infection and spread.



Bacterial soft rot

Scientific name

Erwinia spp.

Host

Most vegetables

Damage symptoms

Soft rots cause the fruit to develop soft and moist lesions, with the flesh rotting and causing a foul odour around the affected area. A slimy layer will also appear over the lesions.

Life cycle

This bacterial pathogen lives in rotting vegetable matter and crop residue in the soil. Insects, soil movement, irrigation and poor crop hygiene spread the infection. The pathogen mostly infects the crop via wounds that may have been caused by insect, disease, or mechanical damage. The pathogen can spread rapidly in warm, moist conditions. The bacteria also spread between produce in storage.

Management options

Cultural

- Crop hygiene is the best preventative control for soft rots.
- Cleaning harvesting and packing equipment will reduce the spread of the pathogen.
- Handle produce carefully to reduce injury damage.
- Store produce in a temperature controlled environment and minimise storage time of produce that has a short shelf life.
- Avoid wet conditions while harvesting.

Black leg

Scientific name

Erwinia spp.

Host

Potatoes

Damage symptoms

Black leg is a bacterium that causes a black, slimy rot to appear on the lower stems of the plant. The rot usually first appears on decaying mother tubers (sets), then spreads to the stems and eventually right up through the canopy. The leaves of infected stems turn yellow and curl, wilt and often show signs of distorted growth. Infected tubers tend to show signs of vascular discolouration on the stolon end with the entire tuber eventually rotting. Tubers can also be infected via lenticels and harvest wounds. The bacterium may also infect and kill young sprouts before they emerge.

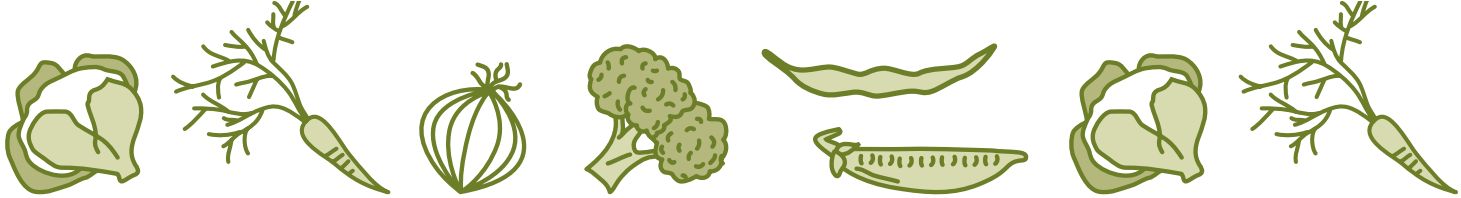
Life cycle

The primary source of infection is from contaminated mother tubers, either infected internally or carrying disease externally. The seed pieces decay soon after planting and release bacteria into the soil, which is transported by water, contaminating nearby tubers. The bacteria also contaminate water sources such as dams, and can therefore be easily spread by irrigation.

Management options

Cultural

- Use certified seed.
- Good farm hygiene, such as washing down machinery and cleaning and disinfecting cutting equipment will reduce seed infection.
- Avoid planting in cool wet conditions and avoid waterlogging from excessive irrigation.
- Cure cut seed to prevent early breakdown of the plant set.



Bloat nematode

Scientific name

Ditylenchus dipsaci

Several types of nematodes live in the soil. Some are beneficial and others, like bloat nematode, cause problems in vegetable growing areas. Plant parasitic nematodes cause damage by using their small sucking mouthpart to feed. They live in the soil and can easily spread by water or soil movement.

Host

Onions, peas, beans, lettuce, clover - wide host range.

Damage symptoms

Bloat nematode is abundant where host crops have been grown frequently. The nematode feeds primarily on the roots and on the lower stem of the crop, causing young seedlings to become distorted and eventually die. Later attacks occur on the mature leaves, in which case they become stunted, causing the leaves to bend over. The stems of onions will swell (bloating) and rot. The bulb may also split.

Life cycle

Bloat/stem nematode is a microscopic worm-like organism which can't be seen by the naked eye unless present in large aggregations 'nematode wool'. The nematode is an endoparasitic organism (feeds inside the host plant) and can survive in a dormant state in the soil for up to ten years, as they have specialised features to tolerate long periods of dryness. In wet and mild conditions, the nematode migrates through the soil via water movement. It will then penetrate the base of the stem causing the plant to become distorted and stunted. The juvenile and adult stages are both capable of causing damage to host plants.

Management options

Cultural

- A minimum rotation of three years is recommended. Planting crops less susceptible to nematode attack, or which can reduce nematode populations, should be included in the rotation program. For example, peas act as a 'catch crop'. Peas are susceptible to nematode damage, but will prevent the nematode from multiplying.

- In areas with a known history of infestation, appropriate hygiene practices should be implemented to prevent the infestation from spreading, as the nematode will reinfest with the movement of soil and water from contaminated areas. Avoid planting in these areas as economic returns will be unlikely and disease will multiply and spread.

Chemical

- Applying nematicides before sowing the crop and in cropping areas with a known history of infestation may be beneficial.

Botrytis neck rot

Scientific name

Botrytis spp. especially *B.aclada* and *B.alli*

Host

All onion related crops – gold onions, red onions, garlic, chives, shallots

Damage symptoms

Outbreaks of neck rot usually appear in storage, causing the onions to soften and rot internally. Identifying the disease early is often difficult, as the plant displays few symptoms until storage. The pathogen is most prevalent in damp areas, such as irrigation runs. In some cases, a grey mould may form on the developing stems or grey-brown spores may be visible between the bulb scales.

Life cycle

Botrytis can be carried in seed, infecting cotyledons as the seedling emerges.

Botrytis alli survives in onion trash and in the soil as small dormant sclerotes. When conditions are moist and the temperature is warm, the sclerotes germinate, releasing small airborne spores. The spores infect localised areas of the leaves. As the leaves senesce the fungus spreads to the neck tissue of the bulb and eventually moves down into the bulb causing the neck and bulb to rot.

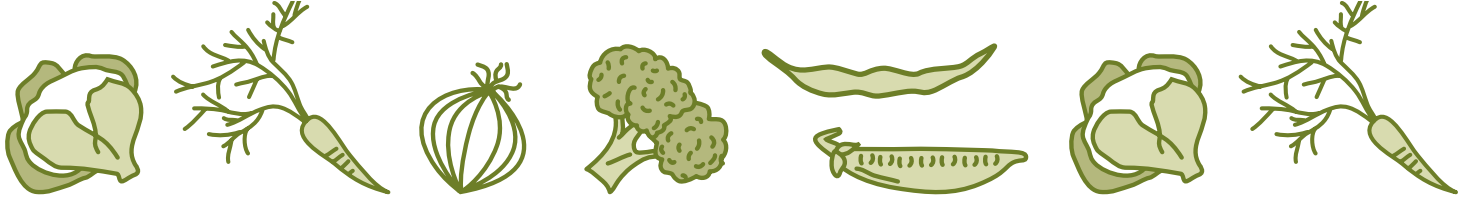
Management options

Cultural

- Use tested seed with an approved fungicide seed dressing.
- Use rotations of at least 3 years and plant non Allium crops. This will prevent the pathogen from over-wintering and building up in the soil.
- Implement good farm hygiene practices, such as destroying and burying crop residue to reduce the number of viable sclerotes in the soil.
- Minimising damage to bulbs during lifting and harvesting, and thorough and rapid curing after harvest, will minimise the spread of the pathogen.
- Neck rot is often found in crops that have high levels of nitrogen. Thick necks favour disease as the fungus can enter the bulb more easily.

Chemical

- Apply approved fungicides during the season to prevent leaf infection.



Club root

Scientific Name

Plasmodiophora brassicae

Host

All brassica plants including brassica weeds

Damage symptoms

The most obvious symptoms of clubroot are the large, rounded, club-shaped galls that develop on the roots. The galls usually develop in the centre of the roots, tapering to small, thread like roots at the end. The galls restrict water and nutrient movement to the plant, resulting in stunted plants which wilt, particularly in the warmer part of the day.

Life cycle

Club root is a fungus that can infect the plant through fine root hairs and small lesions on the stem and roots. Once the fungus has entered the plant, it will cause the roots to grow abnormally, causing the galls or clubs to form. The developing galls hold masses of spores, and once the galls are ruptured, the spores are released into the soil and the disease continues on with the cycle. Contaminated soil that is moved by machinery, water and wind is the primary means of spread and source of infection.

Management options

Cultural

- Do not plant brassicas in areas of paddocks when high levels of disease have occurred in previous crops.
- Use crop rotations of about 3-4 years, planting non-brassica crops to prevent as much spore build up as possible.
- Crop hygiene is crucial to prevent the spread of soil from infected paddocks to non-infected paddocks. Disinfect and wash-down all machinery and footwear before entry to and after leaving paddocks.
- Clubroot prefers a low pH soil. Liming the soil to a soil pH of 7.0 can assist with control. Lime should be applied about three months prior to crop planting.

Chemical

- Fungicide applied in conjunction with lime at planting has shown some control of the disease.

Common scab

Scientific name

Streptomyces scabies

Host

A wide host range including potatoes, beets, radish, carrot and parsnip

Damage symptoms

Common scab symptoms can vary depending on the potato variety and the population of the pathogen. The first signs of infection are minute reddish-brown spots on young developing tubers. As the disease ages, visible symptoms may appear as one or more of the following forms:

- superficial, 5 mm, circular, rusty-coloured lesions
- brown, star-shaped, crater-like lesions (5-15 mm)
- larger lesions (1-2 mm) which are often raised
- deep, pitted lesions.

Each symptom can appear on just one tuber. Tuber symptoms can easily be confused with those caused by powdery scab, root knot nematode and Rhizoctonia. Tasmania's main processing potato variety, Russet Burbank, is considered to be moderately susceptible, but infections can be severe.

Life cycle

Streptomyces is a common soil organism associated with rotting organic matter. Infection occurs in soils with a pH range of 4 to 8 and first infects tubers via lenticels and damaged skin and tissue. The critical time when tubers are susceptible to infection is over several weeks, usually starting at early tuber initiation, and when soil conditions are dry. There is also a high risk of scab infection following lime application. The Streptomyces organism secretes a toxin that causes the tubers to produce a corky barrier. As the tuber grows, the corky layer tears and the process of new infection and new corky layer formation continues.

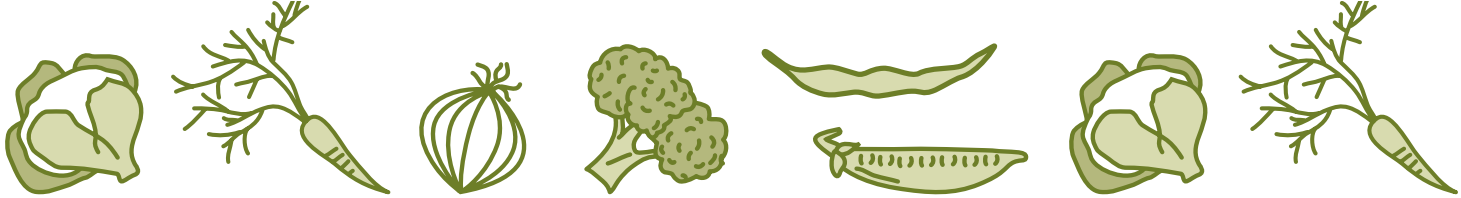
Management options

Cultural

- Use only certified seed and ensure a minimum crop rotation of four years.
- Ensure adequate irrigation during the susceptible period from the start of tuber initiation onwards for about six weeks. (note - excessive irrigation may favour the development of powdery scab)
- The use of soil moisture monitoring devices to determine water deficit is recommended.
- Avoid liming paddocks prior to planting potatoes.

Biological

- Varieties differ in their susceptibility.
- Some work is being carried out on breeding resistant strains of Russet Burbank but these are not ready for commercial use yet.



Downy mildew

Scientific name

Peronospora destructor - affects onions,

Peronospora viciae – affects beans and peas

Peronospora parasitica – affects brassicas

Host

Onions, peas, beans, brassicas

Damage symptoms

Onions: Damage usually occurs to the older leaves first, with pale green-yellow spots developing on the infected plant. These may eventually become a brown-purple colour as the disease develops.

Beans/Peas: White spots may appear on the lower leaves at first, gradually enlarging and causing the leaves to die off. Damage symptoms may appear on the pod where a distinctive white cottony patch will be evident.

Brassicas: Small, round, pale green-yellow lesions appear, usually on the underside of the leaves.

Life cycle

Downy mildew rests in infected plant material left in the paddock and in the soil as oospores. These spores can remain in the soil and infect the host planted the following season. Throughout the growth of the host plant, the fungus produces spores (conidia) which are carried via wind to nearby plants. The release of the spores is temperature dependent. Spores are produced at night when humidity is high and temperatures are between 4-25°C. The spores land on the host plant and will germinate if conditions are warm and water is present. The fungus becomes established on the host plant and will complete its life cycle in about two weeks, with new spores continually being released and infecting the plant and new plants. Spore germination will decline if conditions become too dry, but will recommence as soon as moisture is present.

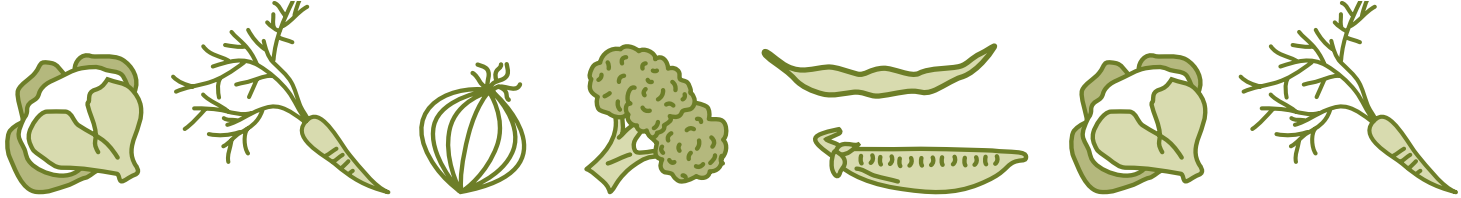
Management options

Cultural/Mechanical:

- Avoid overhead irrigation if possible. Irrigating pre-dawn or early morning may result in reduced disease compared to irrigating in the evening due to shorter periods of leaf wetness. The spores spread and germinate once they are released and come into contact with water. Good soil drainage is also recommended.
- Destroy volunteer plants and crop debris as this is a source of infection for the next crop.
- A two year crop rotation with non-susceptible plants is also necessary to break the cycle.
- Use certified, disease free seed and regular crop monitoring.
- Orientate rows to improve airflow through the canopy to delay onset of the disease.

Chemical

- Preventative fungicides should be applied when early symptoms of downy mildew are present and when environmental conditions are favourable for disease sporulation and infection.
- A forecasting system (DOWNCAST) which predicts outbreaks of downy mildew based on weather conditions has been used effectively to time fungicide applications.



Fusarium root and stem rots

Scientific name

Fusarium solani

Host

Wide host range including peas, beans and potatoes

Damage symptoms

The symptoms of root rot appear as red-brown discolourations that cover the root and stem below the soil line. The plants usually become stunted, and in warm conditions the foliage will often turn yellow and fall off.

Fusarium root and stem rot mostly occurs when plants are exposed to the pathogen at the same time as being stressed from adverse environmental conditions, such as herbicide application and soil compaction which restricts root growth.

Life cycle

The fungus is soil borne and enters the roots of the host plant and moves slowly throughout the plant root system. The fungus produces spores that are easily spread by wind, rain, water and machinery. The fungus can live on dead plant tissue and can over-winter as mycelium or spores in infected or dead tissue.

Management options

Cultural/Mechanical

- Use a crop rotation to prevent build up of the disease.
- Provide good soil drainage.
- Use clean and healthy seed.

Biological

- Some success has been achieved with incorporating organic material (barley, straw) into the soil to increase and favour several antagonistic fungi and bacteria, although this has not been used in commercial practice.

Chemical

- Fertilisation with the nitrate form of nitrogen may reduce the disease.
- Use fungicide coated seed to prevent disease infection.

Fusarium wilt

Scientific name

Fusarium oxysporum

Host

Peas, beans and tomatoes

Damage symptoms

Plants that are infected at the seedling stage will often wilt and die once symptoms become visible. Mature plants will do the same if the infection is severe and the weather is favourable. However, in most cases, the first symptoms appear as slight vein clearing on the younger, outer leaflets of older plants. The leaflets and stipules will tend to turn yellow, wilt and curl downwards. The plant will eventually die. The symptoms usually appear on one side of the stem and slowly move up the plant, killing the plant as it spreads. In beans, pods may also become infected causing them to rot and drop off, and infected roots become stunted.

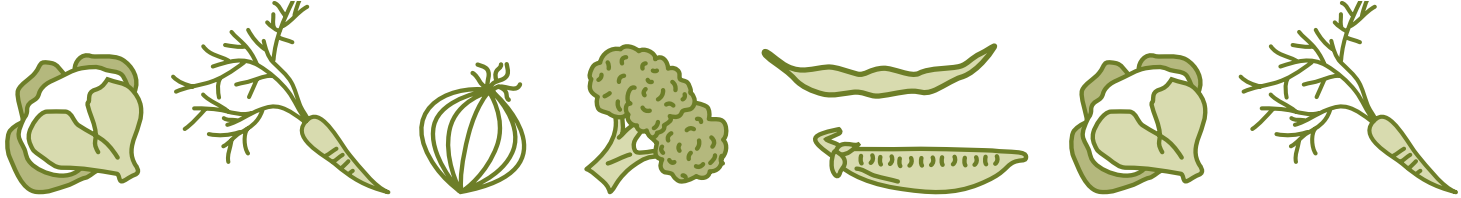
Life cycle

The pathogen is soil borne and survives in infected crop debris within the soil as spores and mycelium. It is easily spread in water or through the movement of infected soil. Fusarium wilts are favoured by warm soil conditions. When healthy plants are grown in infected soils, the spores and fungal threads (mycelium) attack and enter the plant via the roots. The mycelium then moves upward towards the stem and crown of the plant. As it moves through the sap stream of the plant, small spores are produced and released. The spores germinate and form more mycelium. The cells of the host plant become clogged and the plant eventually dies.

Management options

Cultural/Mechanical

- Use resistant varieties if available.
- Avoid planting in known infected paddocks.
- Rotate pea and bean crops with other crops.
- Sterilise seedbeds, particularly in greenhouse situations.
- Use healthy seed.
- Hot water treatment of seed suspected of being infected should be done prior to planting.



Irish blight / late blight

Scientific name

Phytophthora infestans

Host

Potatoes and plant species that are related to potatoes, tomatoes and black nightshade

Damage symptoms

Symptoms will first appear as small irregular or circular, water soaked lesions on the tips of the lower leaves. The lesions spread rapidly over the plant canopy and stem and eventually down into the tubers. As the infection matures, the lesions become large (3-5 mm) and brown. When conditions are wet or humid, the organism produces threads of growth called mycelium which can be visible on the margin of the lesions on the underside of the leaves. Irish blight can cause severe destruction of all plants within a couple of weeks when conditions are cool and when no preventative control is used. Infected tubers show signs of darkened blotches, and when cut open the infected area appears water soaked, becomes dark and extends deep into the flesh of the tuber. The lesions will gradually harden. New strains which are resistant to many fungicides, have become common overseas but have not yet occurred in Australia.

Life cycle

Phytophthora survives as small, white, thread-like structures called mycelium and as resting spore structures called oospores. Under moist conditions, the mycelium will invade the growing sprout of the emerged crop and produce spores. The swimming spores are spread into the surrounding plants by wind or water. Infection will occur when leaves have been wet for more than 5 hours (from dew, rain or irrigation) and when temperatures are around 15-20°C.

Management options

Cultural/Mechanical

- In blight prone areas, monitor the crop regularly during high risk weather conditions ie. wet and warm. Early action is essential to prevent crop loss.

Chemical

- Preventative fungicides can slow the development and spread of the disease. They should be applied BEFORE the crop canopy closes to ensure protection of lower leaves.
- Treat with a registered curative fungicide (eg. metalaxyl) on the first signs of disease infection.
- Forecasting programs eg. (BLITECAST) are used in some locations to predict outbreaks of late blight based on environmental conditions, and allow better timing of fungicide applications.

Onion white rot

Scientific name

Sclerotium cepivorum

Host

All onion crops – shallots, red onions, gold onions, chives, garlic

Damage symptoms

Onion white rot is the most destructive disease affecting the onion family. Once the disease is in the soil, it is extremely difficult to eradicate. Onion plants will show signs of yellowing, stunting and wilting. This is usually noticeable in localised areas throughout the paddock. The plants can be easily pulled from the soil as the roots are the primary target of the disease. The roots will show signs of white, fluffy looking mycelial growth. Small black poppy seed-like fruiting bodies (sclerotes) are often present on the infested parts of the plant.

Life cycle

Onion white rot can persist and survive in the soil for up to fifteen years, even without a susceptible host. When the diseased plants are lifted, the surviving sclerotes fall from the plant and will remain dormant in the soil until a susceptible host is planted. An exudate from the onion roots stimulates the germination of the sclerotes, allowing the pathogen to spread and the lifecycle to start again. White rot activity is also temperature dependant. The sclerotes will become active once the host is present and the temperature is between 10-20^{o}C .

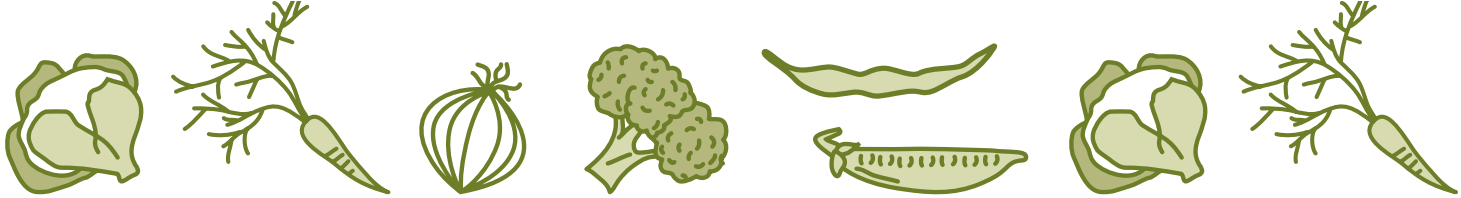
Management options

Cultural

- Quarantine is the best method for avoiding white rot from entering your farm and spreading.
- The pathogen can easily spread via footwear, machinery and seedlings. Wash down and clean machinery and footwear to reduce the spread of the disease.
- Removal of infected plants and soil is necessary to prevent further spread.
- Stimulants such as garlic oil, applied several months in advance of sowing the crop encourages germination of sclerotes. With no onion crop present, the stimulated sclerotes will die due to lack of food.
- Adjust planting date. Crops planted in late spring in warmer temperatures are less affected by the disease. Late winter sown crops are very susceptible to infection as cold soil temperatures favour the disease.

Chemical

- Approved fungicides applied with lime super at planting.



Pink rot

Scientific name

Phytophthora erythroseptica

Host

Potatoes, but can also live on decaying plant material and on the roots of many plants, including cereals and grasses

Damage symptoms

Pink rot symptoms will cause the tubers to take on a rubbery appearance and tubers will leak if squeezed. The tubers will turn pink when cut and then blacken over a few hours. The skin tissue covering the diseased area is usually discoloured and loose with darkened lenticels. Symptoms may also cause yellowing and wilting of the plant leaves. Aerial tubers may develop in some cases. Infection is usually localised in the paddock, and generally found in areas that are over irrigated and on soils that are prone to waterlogging. Infected tissue has a distinctive odour that may be detectable in infected areas of the paddock.

Life cycle

The disease survives in soil for many years as resistant spores (zoospores), as well as on decaying plant material and other species such as cereals and grasses. The spores can survive for more than 3 years in pasture between potato crops. The disease is favoured by warm weather and water logged soils, with spores being released in warm conditions (20-30^{o}C) following heavy rain or irrigation.

Management options

Cultural

- Monitor for symptoms, especially in potato crops sown after pasture or cereals have been grown.
- Look for isolated infection sites.
- Do not plant in known infected areas as plants in these areas are most likely to fail.

Chemical

- Some control can be gained from applying the registered fungicide treatment of metalaxyl to soil prior to planting, or to foliage early in the crop life. Follow label directions to acheive effective control.

Powdery mildew

Scientific name

Oidium spp.

Host

Has a wide host range but not particularly common

Damage symptoms

All plant parts can be attacked by powdery mildew, with the first symptoms being very small white, round imperfections on the stems and leaves. As the disease progresses, the white powdery mass will quickly cover much of the leaf surface. The plant may show signs of wilting, and the leaves may appear to curl over and become distorted. In severe cases, the crop may die as the fungus completely smothers plants.

Life cycle

Powdery mildew over-winters as mycelium in plant residue, or as fruiting bodies on the live or dead host. These fruiting bodies eventually produce spores which spread the disease via wind, water and movement of infected material. Spores will land on the host plant, and germinate when conditions are warm and moist. Autumn and summer are the most susceptible times of the year.

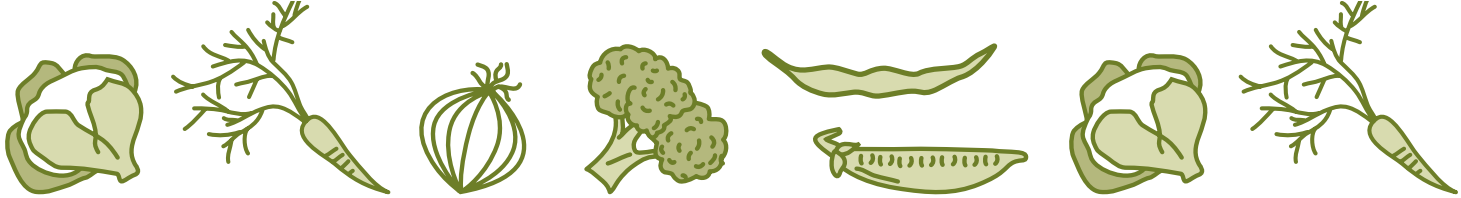
Management options

Cultural

- Wide spaced rows oriented towards the prevailing wind direction will ensure good crop ventilation to prevent warm, humid conditions developing within the crop.
- Removing diseased plants will reduce the amount of inoculum available for further infection.
- Use resistant varieties if they are available.

Chemical

- Both protectant and curative fungicides can be used.
- Sprays should be applied when the very first symptoms appear. The disease spreads rapidly, and delaying any control measures can cause extensive crop damage.
- The plant has to be completely covered with spray, and a fine mist will enable both sides of the leaf to be covered.
- Spraying should take place in calm conditions at a cool time of the day.
- On peas, a spray is only likely to be cost effective if disease appears before flowering. Two sprays should be applied to ensure protection of new growth.
- Where disease is severe, overhead irrigation can remove spores prior to spray application and improve chemical control through reducing disease pressure.



Powdery scab

Scientific name

Spongospora subterranea

Host

Potatoes, black nightshade and tomatoes, rape and turnip roots.

Damage symptoms

The first signs of infection usually appear on the roots, with small, light coloured galls about 1-10 mm long developing. Infection on tubers usually appears as light coloured pimples or warts that erupt through the skin and are about 2-10 mm long. As soon as the warts are exposed to air, they become brown and powdery. The severity, size and shape of the lesions varies with potato varieties, with symptoms often being mistaken for common scab.

Life cycle

Powdery scab is common in potato growing soils. The disease survives as spores that are usually found in clumps or 'spore balls'. The clumps are able to survive for many years in the soil without the host being present. The disease will persist in the soil if volunteer or secondary potato plants are present. The pathogen can infest soils through the movement of contaminated seed and soil or by movement of stock which have eaten contaminated potatoes.

Management options

Cultural

- Use only certified potato seed.
- Use a minimum rotation of 4 years.
- Avoid paddocks that are known to be severely infected.
- Ensure adequate irrigation during the susceptible period from the start of tuber initiation onwards for about six weeks. However, excessive irrigation and wet periods favour infection.
- Remove all volunteer potato growth. The spores will over winter and survive on these hosts.

Pythium or damping-off

Scientific name

Pythium spp.

Host

Many vegetable crops

Damage symptoms

Pythium spp. are one of the most common fungi that causes pre- and post-emergence damping off. Several other fungi, such as Rhizoctonia and Fusarium, cause symptoms very similar to Pythium. Other fungi, such as Septoria, Botrytis and Colletotrichum can also cause damping-off and kill young seedlings.

Infection usually occurs on the roots and stems of young plants. The initial infection occurs just below the soil line. The fungus attacks the plants, causing the plant cell walls to break down and the plant to collapse and die. Severity of the disease is usually greater when:

- the soil is wet for a long period,
- the plant is stressed due to adverse environmental conditions
- there is an excess of nitrogen in the soil; and
- there is no crop rotation.

Life cycle

The fungus attacks young seedlings when conditions are not favourable for seedling growth, such as cold wet conditions. Pythium overwinters on crop residue as small, reproductive structures called oospores and is spread by the motile spores called zoospores These spores tend to infect the plant roots. The spores require water to spread through the soil.

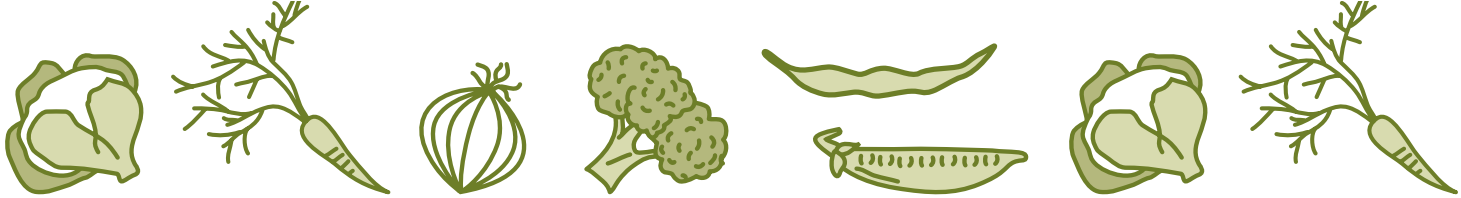
Management options

Cultural/Mechanical

- Soil sterilisation can be used to remove the fungus in glass house situations.
- Ensure storage conditions are free from condensation and free water.
- All equipment should be thoroughly sterilised or cleaned.
- Improve soil drainage, such as with the use of raised seedbeds.
- Increase air flow throughout the crop by increasing plant spacing.
- Plant when conditions favour plant growth, thereby reducing stress on the plant.
- Have a 2-3 year crop rotation with non-susceptible crops in infected paddocks.
- Care should be taken in hydroponic systems to prevent contamination of water supply.

Chemical

- Seed should be treated with a registered fungicide.



Rhizoctonia/Damping -off/Wire stem

Scientific name

Rhizoctonia spp.

Host

Many vegetable crops including carrots, peas, beans, lettuce and potatoes

Damage symptoms

The most common symptoms are damping-off of seedlings and root and stem rots, development of stem canker on plants and storage rots. Damping-off is the most common symptom caused by Rhizoctonia and usually occurs in soils that are cold and wet. The fungus attacks the tip of newly emerged seedlings causing them to die shortly after infection. The fungus can also attack older seedlings, causing the outer tissue near the base to develop reddish-brown lesions which gradually spread around the plant. The plant may die or in some cases the stem may darken and bend or twist without breaking, developing a symptom called 'wire stem'.

Rhizoctonia will attack the leaves near the ground of plants such as brassicas and lettuce. The mid-rib and veins of these leaves develop reddish-brown, sunken lesions, with the entire leaf eventually becoming brown and slimy. Rhizoctonia also causes rots on the pods of beans and peas. Water soaked lesions will first appear, with the infection area gradually collapsing. The pods will appear dry and turn brown, allowing soft-rotting bacteria to invade. Infection of aerial parts would require high humidity and warm temperatures. This is not common in Tasmania where most infections occur from soil contact.

Life cycle

Rhizoctonia over-winters as mycelia in crop residue and plant debris, or as sclerotia in the soil. The fungus is able to survive many years in the soil as part of its microflora. The fungus spreads by rain, irrigation and movement of infected machinery, and will initiate infection when temperatures are around 15-18°C. Rhizoctonia spreads rapidly in wet and waterlogged soil. Crops that are slow growing due to adverse environmental conditions are also more prone to infection.

Management options

Cultural/Mechanical

- Wet and poorly drained soils should be avoided or drained.
- Sow seeds into raised beds to encourage drainage and rapid plant growth.
- Increase plant spacing to improve crop aeration.
- Use a minium three-year crop rotation to break the pathogen life cycle.
- The fungus can multiply in organic matter in soils and may be more prevalent in soils containing high levels of such matter ie. long term pastures returning to cropping.

Chemical

- Registered contact and systemic fungicides can provide effective control.

Root-knot nematode

Scientific name

Meloidogyne spp.

Host

Wide range of hosts including carrots, tomatoes, beans, potatoes and onions

Damage symptoms

Root-knot nematodes are microscopic worm-like organisms that are very common in soil. Root-knot nematode can kill emerging seedlings. When older plants are attacked the nematode causes taproots to fork, and galls and lumps to develop on lateral roots. They do not cause any distinctive above ground symptoms, but affected plants may show signs of stunting and wilting, with symptoms becoming visible soon after planting. As the plant matures, and nematode numbers increase, the plant may wilt and possibly die.

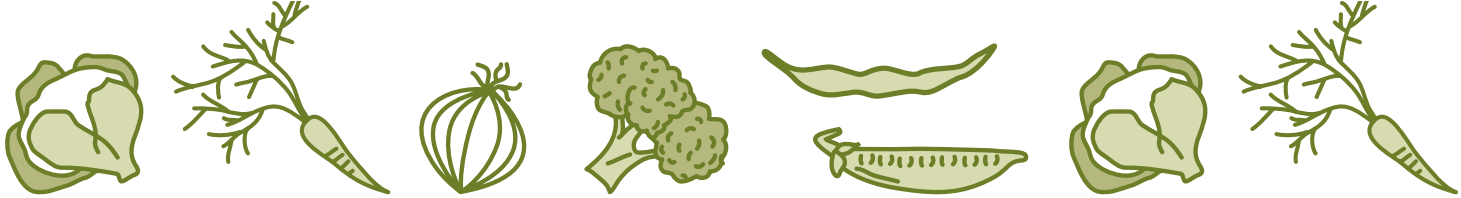
Life cycle

The female nematode lays hundreds of eggs on the root surface of the host plant. The juvenile nematodes will emerge when soil conditions are warm and moist. The juveniles are about 0.5 mm long, making them difficult to see with the naked eye. The nematodes move via a thin film of water to penetrate the plant roots. Small galls will then develop on the roots. The lifecycle of the root-knot nematode is temperature dependent and can take up to six weeks to complete in the summer, and up to fifteen weeks in the winter.

Management options

Cultural

- Green manure crops are known to become infected by, but do not mulitply the nematode and may reduce the numbers in the soil.
- Planting non-susceptible host crops, such as winter cereals, between susceptible crops will reduce nematode root knot populations.
- Highly susceptible crops will rapidly multiply nematode numbers in the soil.
- Soil cultivation may reduce nematode numbers.
- The paddock should be weed free to prevent nematodes from surviving on weedy hosts.
- Conduct a nematode count prior to harvest of the previous crop to ensure the best chance of detecting root knot nematode.
- French marigolds are believed to suppress nematodes and in severly infested paddocks may reduce the population.



Chemical

- Fumigation of the soil, particularly seedbeds in which seedlings are established, can be an effective means of control.
- Nematicides should be used in severe cases and in conjunction with all other management practices. They should be applied before the crop is transplanted.
- Fumigants and nematicides are prone to enhanced biodegradation when regular application to soil leads to a build up of soil micro-organisms which can break down the chemical and render it ineffective.

Rust

Scientific name

Uromyces spp.

Host

Beans, grass and cereals

Damage symptoms

All parts of the plant may be infected with rust, with yellow spots or blisters first appearing on the upper surface of the leaves, pod and stems. These gradually turn orange-brown with a pale halo-like colouring around the infection. These rusty looking markings contain hundreds of spores which, when disturbed, are easily dispersed into the air to create further infection.

Life cycle

The rust produces small spores (urediniospores) which are released from the fruiting body or uredinium, and are spread to nearby host plants via wind, water splashes and movement of infected plant material. The spores infect the healthy plant and within 10-14 days symptoms will appear on the plant. The disease cycle continues with spores being released. Rust over-winters as spores either on the host plant, on plant debris or on nearby weeds that are host plants. High humidity and moderate temperatures favour the spread of the disease.

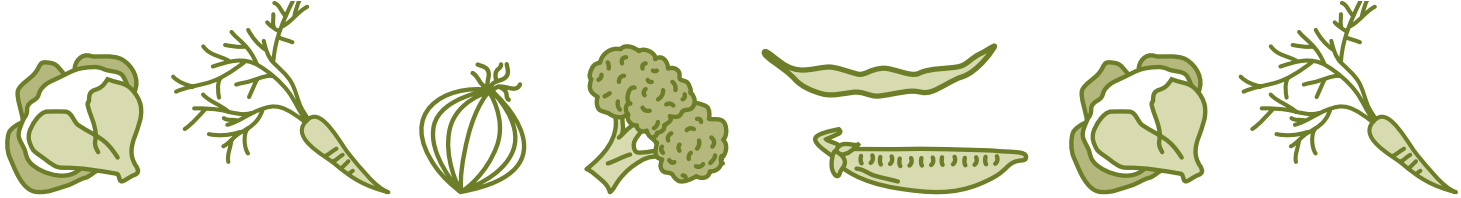
Management options

Cultural

- Increasing plant spacing to improve crop ventilation and reduce micro-climate humidity may be effective.
- Remove infected plants to reduce the amount of inoculum that over-winters.
- Rotation and planting away from any adjacent infected site will prevent re-introduction of the disease into a new crop.

Chemical

- Fungicides should be applied at the first signs of rust, as they will not be effective once the disease has become well established.



Sclerotinia

Scientific name

Sclerotinia sclerotium, S. minor

Host

Many vegetable crops including carrots, peas, beans, lettuce, brassicas and potatoes

Damage symptoms

Symptoms appear on most parts of the plant. The symptoms vary from host to host, but the most obvious is the appearance of white fluffy mycelial growth. This mycelial growth eventually develops small, hardened, black, resting spores called sclerotia. The sclerotes first appear white and gradually blacken and harden. The stems first develop small, pale, darkened lesions close to the base, with the white mycelial growth quickly covering the lesions. The stem will gradually weaken and rot, causing the leaves above the lesions to wilt and die.

Life cycle

The fungus over-winters as spore like structures called sclerotia (which look like mouse droppings) on infected host tissue or as mycelium (white fluffy mass) in dead plant tissue. The spores can remain viable in the soil for more than three years. The sclerotia usually germinate in the spring and in early summer produce mycelium or in the case of *S.sclerotium* form tiny mushroom-like structures that produce spores for dispersal. The spores (ascospores) are released and spread by wind to a susceptible host. The spores germinate on the host and create the infection. High soil moisture and high air humidity favour disease development. Flowers and leaf axis where water droplets sit are also common infection sites.

Management options

Cultural/Mechanical

- In greenhouse soil, sterilisation with steam kills the pathogen.
- Susceptible plants should only be planted in well drained soils, with adequate plant spacing to improve air flow.
- In severe cases, infected plants should be removed immediately and destroyed to prevent the fungus from forming over-wintering sclerotia.
- Reduce plant density to improve ventilation.

Biological

- There have been reports from overseas of several fungi, bacteria and insects parasitising sclerotinia. However, specific recommendations are yet to be made.

Chemical

- Application of registerd fungicide.
- Applications of lime to the soil surface have been shown to prevent the formation of the fungus fruiting bodies that produce spores.

Septoria

Scientific name

Septoria spp.

Host

Many species of this fungus attack a wide range of hosts including carrots, brassicas, potatoes, peas and beans

Damage symptoms

The most noticeable symptoms begin as small, yellowish, speckled leaf spots. The spots gradually enlarge, changing from yellow to a pale brown and eventually dark brown. A distinct yellow halo will surround the darkened spots. The spots can vary in size from barely visible to 1-2 cm in diameter and tend to vary depending on the host. Some spots are circular while others may be irregular. Small, blac,k spore-producing bodies called pycnidia will appear in the centre of the lesions.

Life cycle

The noticeable small black fruiting body called the pycnidia produces spores (conidia) when conditions are wet. The conidia are then released and spread via rain droplets, irrigation water, wind and movement of infested soil. The conidia over-winter as mycelium or as conidia within the fruiting body (pycnidia) in or on crop residue. The pathogen may cause severe damage when temperatures are in the 10-27°C range.

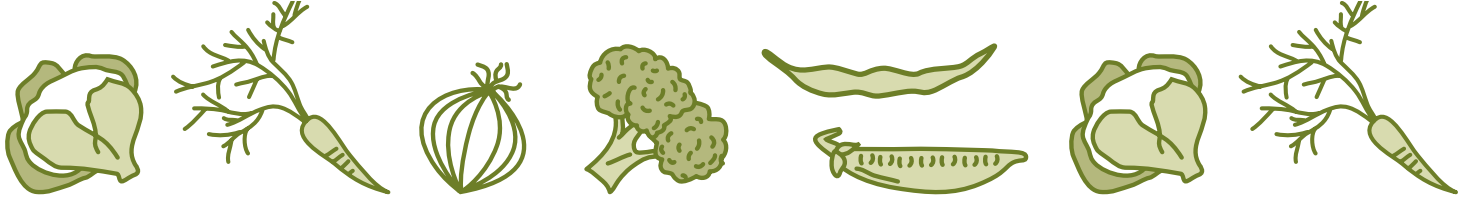
Management options

Cultural/Mechanical

- Use disease free seed in a paddock that is known to be free from the fungus.
- Use a 2-3 year rotation of non-susceptible crops in infected paddocks.
- Remove infected plant residue.

Chemical

- Application of registered fungicides can assist with management.



Target spot or early blight

Scientific name

Alternaria solani

Host

Mostly potatoes, but will also develop on species related to potatoes such as tomato and nightshade

Damage symptoms

Symptoms usually do not appear until the foliage matures or the plant is under stress. Small (2-20 mm) dark brown to black concentric, ring-like lesions may appear on the leaves, with the leaf veins usually confining the growth of the lesion. Leaves surrounding the infection site may appear to be yellow and withered. The infection can affect tubers in severe cases, although these symptoms are rarely seen in Australia.

Life cycle

Alternaria survives as spores on potato debris and on related species (nightshade and tomato). Water and wind spread the spores, usually in the spring months. Primary infection then occurs on the lower leaves of the host. However, infection may not be obvious on healthy plants until after flowering. Spores that are then produced from the primary infection site move through the crop canopy, resulting in new infections within days. The disease favours temperatures around 10-35°C, with rapid development and spread favoured by periods of wetting and drying.

Management options

Cultural

- Keep the crop healthy with adequate nutrition and water to prevent stress and premature senescence.

Chemical

- Monitoring for signs of infection on older leaves helps with timing of sprays.
- Several fungicide sprays are registered to reduce spread, but they need to be applied early and with good coverage.

Appendix E - Insects in detail

Armyworms

Scientific name

Southern armyworm - *Persectania ewingii*

Common armyworm - *Mythimna convecta*

Pest description

The caterpillars of the two different types look similar, but the moths differ. Southern armyworm moths are silvery-grey and more common in Tasmania than common armyworm moths, which are fawn. Both moths are about 20 mm long when resting. Southern armyworm moths fly in spring and autumn whereas common armyworm moths appear in summer.

The caterpillars of both are stripey, yellow-brown but can be distinguished by microscopic features. The young caterpillars are pale yellow-cream in colour. They will develop a pattern of grey, white and black stripes along their body as they mature. A distinct 'collar' marking of three parallel white stripes just behind the head distinguishes the armyworm from other similar species (cutworms and budworms).

Host

Pasture species

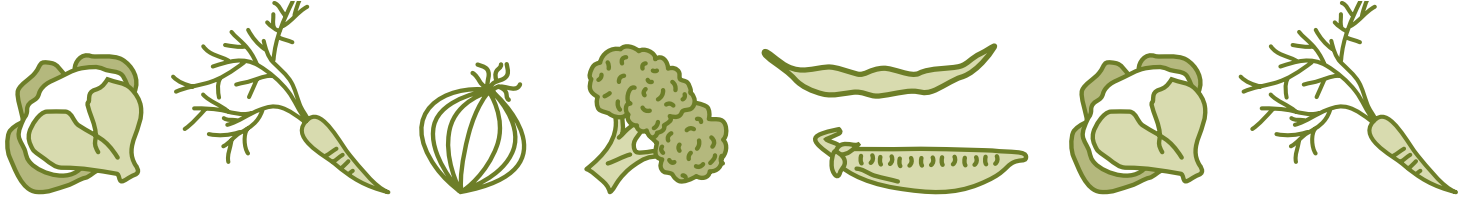
Damage symptoms

The caterpillar (or larval) stage causes most damage to plants when they are older. They feed at night and eat the foliage of clovers and grasses. When cereal plants dry off the caterpillars bite through the stems near the base of plants where the last of the moisture is held. Although they may still feed throughout the day, they are mostly inactive and lie curled up at the base of the plant or just beneath the soil.

Life cycle

Eggs are usually laid in the sheaths of grass foliage, and once the caterpillar has emerged, will go through several moults before reaching the pupal stage. Moths seem to prefer to lay eggs in longer grass, such as pastures that are left to grow for hay production.

Both species of armyworm regularly immigrate from mainland source areas, although the southern armyworm also goes through two lifecycles per year in Tasmania. The Southern armyworm immigrates in early spring, while local moths emerge in late spring. These give rise to a generation of moths in autumn. Common armyworm does not over-winter in Tasmania, but moves south across mainland States via an intermediate generation through spring and reaches Tasmania in summer. Egg incubation diminishes from around 3 weeks in early spring to 1 week in summer. Caterpillars take several weeks to grow in spring and summer, but much longer in winter. The pupal stage may pause briefly so that moths emerge in autumn.



Management options

Cultural

- Use pest-forecasting updates issued by the Department of Primary Industries, Water and Environment.
- Monitor your pastures for signs of armyworms once a warning has been given.
- Monitor the crop regularly, looking at the base of plants and in the soil around the plant for the larvae.

Chemical

- Spray at dusk when the grub is feeding so they are more likely to come into contact with the insecticide. The smaller grubs are not as active in their feeding and tend to hide down the base of the plant, making them difficult to control with insecticides.
- Use registered insecticides.

Cabbage white butterfly

Scientific name

Pieris rapae

Pest description

The adult Cabbage white butterfly (CWB) is easily identified by large white-grey wings with a slight tinge of yellow. The wings usually have a black spot on the front which identifies the sex of the moth. The moth can range from 40-50 mm long.

CWB eggs are usually laid singly, are roughly conical in shape, and protrude 1-2 mm above the surface of the leaf. The larvae or caterpillar can reach up to 30 mm long when fully grown. The larvae are a velvety green colour with fine hairs over the body surface. The larvae actively feed at night. The larvae may be found resting along the plant midrib lines and in the head stem of broccoli and cauliflower plants during the day.

Host

The caterpillar feed on all brassica plants, including forage crops, brassica seed crops, broccoli, cauliflower, brussel sprouts and brassica weeds.

Damage symptoms

The caterpillar stage of the CWB feeds on both sides of the leaf, eating out large irregular holes and leaving small, dark-green droppings around the feeding area. The grubs can also cause serious damage to the heads of cauliflower and broccoli plants making them unmarketable. The caterpillar often shelters in the head of the plant causing contamination issues during harvesting.

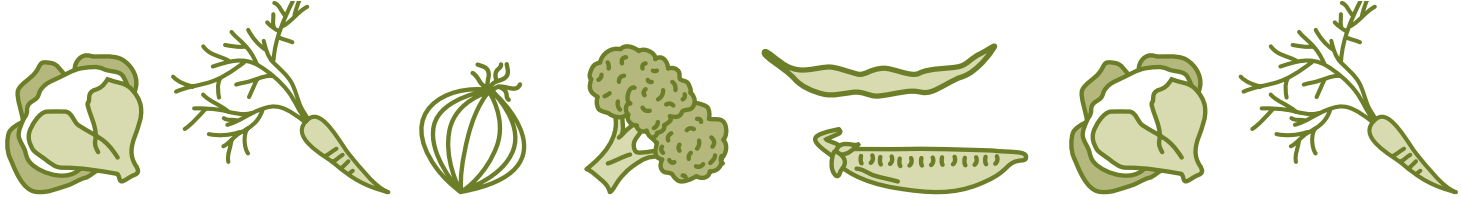
Life cycle

CWB goes through complete metamorphosis, that is, egg to caterpillar, to pupa and finally to adult. The CWB will over-winter in the pupal stage and adult moths will emerge once temperatures start to warm up. Egg laying will then commence. The eggs are conical shaped and laid on the leafy tissue of brassica plants, with 20-100 eggs laid per adult female. The eggs will hatch within 7-14 days during the warmer months. When the small larvae first emerge, they eat their egg shell and then move on to nearby leaf tissue. The larvae will feed for up to 30 days, reaching 50 mm in length. The larvae will then leave the host plant to commence the pupal stage, usually on vertical overhangs such as trees. The larvae spins a silken pad to attach itself to the object while it goes through the pupation phase. The pupa is usually grey to green in colour with small black markings and distinct ‘spines’ along the back of the cocoon. Once temperatures are suitable, an adult moth will emerge.

Management options

Cultural

- Heavy rainfall and irrigation may wash off and drown eggs and small larvae.
- The use of insect exclusion netting may also be useful in a small scale production system, especially during times of heavy infestation or when the plants are young transplants.



- Plant pollen producing trees and flowers to provide a food source for parasitoid wasps to feed and breed on.

Biological

- Various predators such as ladybirds, lacewings and hover flies feed on the eggs and small larvae of the CWB. Various wasp parasites are also important. If clusters of wasp parasite cocoons are seen on fully grown caterpillars, the caterpillars will soon stop feeding and eventually die. *Cotesia glomerata* and *Pteromalus puparum* are the main parasitoids of CWB. They were introduced into Tasmania by the then Department of Agriculture and have greatly reduced the general abundance of CWB.
- *Cotesia* indicates its presence by clusters of white silken cocoons next to dead caterpillars.
- *Pteromalus* indicates its presence by pinholes in pupa left by emerging microscopic wasps.
- Bt (*Bacillus thuringiensis*), which is a biological insecticide, can also give effective control of very young caterpillars.

Chemical

- Pesticides can be applied for rapid control.
- Monitoring is essential to identify the best time to apply.
- Pesticides will only work when CWB is in its larval or caterpillar growth stage.
- Resistance is not known to have developed in CWB and the cheaper broad spectrum synthetic pyrethroid sprays are registered. Continual application will disrupt the beneficial insect population.

Cutworm spp.

Scientific name

Agrotis infusa, Agrotis munda

Pest description

There are many species of cutworm, but the most common is the Bogong moth or common cutworm. The body of the common cutworm moth is dark grey-black with a wing span of 30-55 mm. The main/fore wings are patterned with lighter spots and the hind wings are usually pale in spring and a sooty colour in autumn. Forewings range from brown to black and grey. The eggs are creamy-white and globular with longitudinal ridges . The eggs can be found in clusters on the small cotyledon leaves of weeds or plants and on bare soil near the base of a plant.

The newly hatched larvae are about 1.5-3 mm long, but when fully grown, their length can reach 50 mm. The caterpillar varies in colour from grey-brown to green or dark pink.

Host

Young broad leafed weeds - fat hen, dock, shepherd's purse, pigweed and dandelion

Crops - onions, brassicas, carrots, peas, potatoes, ornamental crops and field crops

Damage symptoms

If seedlings emerge or are planted into an infested paddock, damage by cutworms can be severe and enormous crop losses can occur within days. Cutworm outbreaks typically occur in young established crops and the caterpillars will move along the "drill line" where the soil allows for softer chewing through young seedling stems. In established crops, cutworms may move higher in the canopy to feed on foliage resulting in skeletonised or perforated leaves.

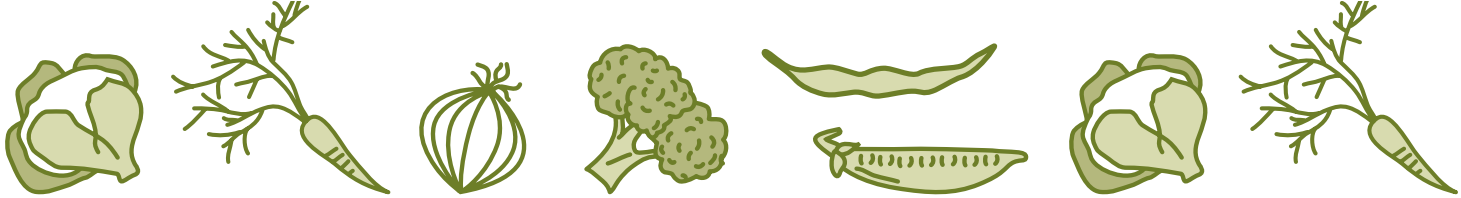
Life cycle

Caterpillars populate inland areas of Victoria, New South Wales and South Australia in the winter months. Moth populations migrate to Tasmania the following spring. They are carried for long distances on easterly and southerly air currents to Tasmanian shores. The moths will lay eggs on moist bare soil and in some cases on foliage. Many moths spend summer sheltering in scree slopes on Tasmanian mountains but some stay on low lands to breed through the summer.

Management options

Cultural

- Cutworms can migrate from surrounding infested crops or weeds, so check paddock edges for cutworm. Also look for perforated leaves on weeds, which may indicate cutworm nearby. You can also monitor fallow paddocks by looking on the underside of soil clods where cutworms hide during the day
- As moths are attracted to lay their eggs on fallow or overgrazed paddocks, reducing the time window between preparation and planting may help minimise the moth laying eggs in the paddock.



Mechanical

- Soil cultivation, such as brushweeding, can destroy the cutworm living in the soil. The brushweeder works only the surface of the soil to remove weeds and will pulverise cutworm living in the soil.

Chemical

- If damage occurs at the seedling stage, chemicals with some stability on soils can be used to achieve quick control.

Diamondback moth

Scientific name

Plutella xylostella

Pest description

The adult moth is about 6 mm long and brown-grey in colour with distinct white-cream diamonds running down its forewings. The eggs are very small (0.5 cm), yellow and are laid singly or in clusters on both sides of the leaf, usually along the mid rib or vein lines on the plant. The larvae vary in colour and size throughout their four growth stages or instars. The young larvae are light green with a black head and are about 1-5 mm long. They change from pale yellow to a darker green as they mature. The fully grown larvae are about 10 mm long, and when disturbed will wriggle and hang from the leaf by a fine silken thread.

Host

All brassica related crops including forage, seed, weeds, vegetable and oil brassica crops

Damage symptoms

Diamondback moth larvae can destroy most brassica crops. Severe infestations can be so destructive that crops have been completely skeletonised, particularly in forage crops. In brassica vegetable crops, the larvae chew the foliage, but also feed and hide in the developing heads, resulting in crops being un-marketable.

When the first instar (growth stage) of the larvae emerges from the egg, it lives and feeds inside the leaf tissue. This type of feeding will show as mines on the leaf, usually with a pin prick hole at the end of the mine where the larvae emerges. The caterpillar will then feed externally on the leaf tissue until pupal stage. The leaf will show signs of 'window' damage from the caterpillars feeding on the leaf. Caterpillars also hide, feed and excrete small green droppings in the heads of vegetable brassicas.

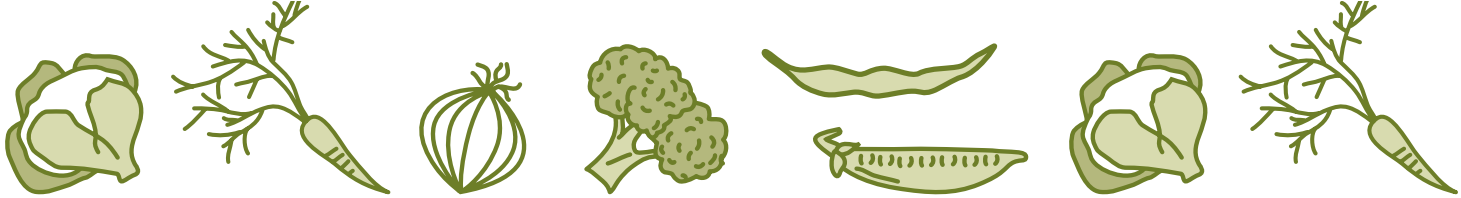
Life cycle

Diamondback moth lay their eggs from mid-spring through to mid- to late summer. On average, an individual will take 3-5 weeks to go from egg to adult moth in a Tasmanian summer. The moths lay their eggs (50-150) at dusk, with the young larvae emerging from the eggs within 3-5 days during the summer months. The very small larvae feed inside the leaf for 3-4 days before emerging and then feed on the leaf surface until maturity, a period of approximately 2 weeks. They shed their skin four times by the time they make a cocoon for the pupa.The larvae then pupate for 7-10 days before emerging as adult moths.

Management Options

Cultural/Mechanical

- Crop monitoring is the key component for effective management of DBM. Monitoring for DBM, beneficials, parasitoids and other pests will determine if and when any control methods need to be applied. Monitoring 10-25 plants will provide information on the growth stage of the pest and what predatory and parasitic beneficials are in the crop.



- Removing brassica weeds will reduce the available food supply for the adult moth. The moths rely on pollen for food and egg production. Removing this pollen source may reduce the number of eggs laid.
- Rainfall and irrigation at dusk (when moths lay their eggs) can reduce egg and grub numbers considerably by washing them off.

Biological

- Accurate application of the biological spray Bt (*Bacillus thuringiensis*) should be applied when the larvae have just emerged from feeding inside the leaf. Two consecutive applications (5 days apart) are most effective. Applying when the larvae are large (4 mm and above) is not as effective.
- There are three effective parasitoids used to manage DBM (*Diadegma rapi*, *Diadegma semiclausum* and *Diadromus collaris*). The wasps sting the larvae and lay their eggs inside the host larvae. The wasp eggs hatch inside the host and eventually emerge as a wasp from the dead pupae of the DBM. They are widely established and greatly reduce overall population.
- Spider and predatory insects such as damsel bugs, the larvae of lacewings, lady birds and hover flies will also eat large numbers of eggs and small larvae of the DBM. Predators and parasitoids are killed when exposed to synthetic pesticides.

Chemical

- Well timed and directed spraying is necessary when applying insecticide. DBM have developed resistance to many of the synthetic pyrethroids due to over use and repetitive applications of the same chemical.
- Insecticides that are 'softer' than synthetic pyrethroids are essential in preserving and protecting beneficials. Some IPM friendly insecticdes are 'softer' than others and vary in their effects on predators and parasitoids.
- Insecticides should be applied only when larvae are actively feeding.
- Insecticides will not kill eggs.

Green looper

Scientific name

Chrysodeixis spp.

Pest description

The adult moths of the green looper have a wingspan of about 3-4 cm. The forewings are a brown-bronze colour with silver, whitish squiggle markings near the centre. The hind wings are usually yellow to grey in colour.

The caterpillars usually go through about six moults or instars before reaching the pupal stage. The young caterpillars are small and green with sparse microscopic black hairs on the body. As the caterpillar matures, faint white stripes may be visible running down the body. At rest, the caterpillar takes on an arched appearance. As they crawl, they move in a 'looping' manner, by holding onto the plant with their front legs and arching the middle portion of their body as they bring in their hind legs.

The mature larvae spin a white, silken soft cocoon on the underside of foliage. The initial pupae are pale brown in colour with distinct dark brown stripes down the back. The pupae soon turns dark brown before it emerges as an adult moth.

Host

General feeders of many vegetable crops including brasscias, corn, green beans, lettuce, peas, potatoes and tomatoes.

Damage symptoms

The larval stage causes the damage to plants. They are leaf eaters and will tend to consume just one side of the leaf, leaving a window like appearance in the leaf. Mature larvae will eat straight through the leaf, leaving holes in the leaf. They also tend to start feeding from the leaf margin and work their way in to the centre.

They rarely cause economically significant loss of foliage in Tasmania and rarely cause cosmetic contamination of produce.

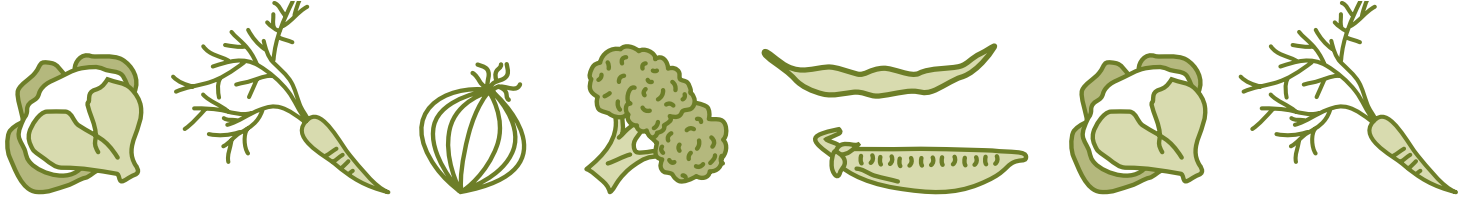
Life cycle

Eggs are deposited singularly on the under surface of leaves, and hatch in about 6 days. Adult females can deposit 300 eggs during their lifespan. There are usually six larval stages. The larval period lasts for about 5 weeks in Tasmanian summers depending on food quality and temperature. The mature larvae spin a thin, white, silken cocoon in which to pupate. The pupal stage can take 2-3 weeks in summer, depending on temperature.

Management options

Cultural

- Monitor hairy leafed weeds which act as nursery plants.



Chemical

- Avoid broad-spectrum sprays. Beneficial insects can usually control green looper.
- Watch pest forecasts based on light trap information. They are a migrant to Tasmania and occasionally abundant.

Green peach aphid

Scientific name

Myzus persicae

Pest description

Green peach aphid (GPA) are small (2-3 mm), round, sap sucking insects that feed on the leaves, stems and fruit of a wide range of crops. GPA adults are usually green to pale yellow in colour. GPA aphid species can be either winged or wingless on the same plant. The wings enable the adult to move from plant to plant when aphid colonies become crowded.

The GPA is a very efficient vector of plant viruses that affect tomatoes, lettuce and potatoes. They have specialised piercing mouthparts that act like a 'hypodermic needle', continually piercing and feeding on plant sap and transmitting viruses in the process.

Host

Most vegetable crops

Damage symptoms

Aphids are sap sucking insects that can affect most parts of the plant. The direct sap sucking injury can, if numbers are high, cause the plant to wilt. The leaves will tend to curl or cup in to protect the aphid colonies, and gradually the foliage will become distorted and mottled. Aphids will also colonise in the marketable part of plants like brussels sprouts and in some cases can lead to crop loss.

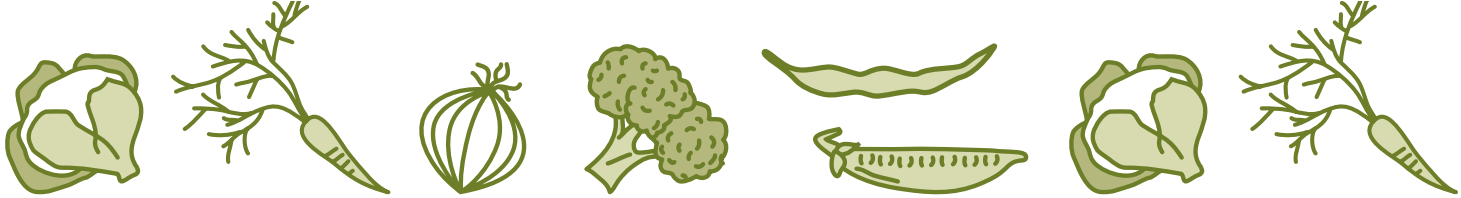
Life cycle

Aphids have a complex life cycle due to having both a winged and wingless stage. The aphid first appears on the plants as a single winged adult and will soon after have a few young wingless aphids surrounding it. The colonies rapidly reproduce, with the active young born alive and not hatched from an egg. During the spring, aphids rapidly multiply, producing wingless females. Eventually, when plant conditions change, or aphid colonies are over-crowded, the winged aphids will migrate to another plant.

Management options

Cultural

- Ploughing in and completely burying old cruciferous plants after harvest will prevent large numbers of aphids from over-wintering and reduce the risk of high aphid infestations in spring.
- Mulches of transparent and blue plastic placed between the crop rows have been shown to deter GPA from brassica crops.



Biological

- Several natural enemies, including the hoverfly, lacewing, ladybird and parasitic wasps provide good control. Aphids that have been parasitised will appear to be swollen and bronze in colour. A small opening or hole will be noticeable at the rear of the aphid, where the parasitoid wasp has emerged.

Chemical

- Synthetic pyrethroid insecticides destroy beneficial insects and usually promote subsequent resurgence of aphids at higher levels than the original infestation.
- As beneficial insects alone can significantly reduce aphid numbers, apply synthetic insecticides with caution so as not to harm the beneficials population. Monitor the status of beneficial numbers before applying any chemical. A yellow sticky trap can be a useful tool for this.
- There are certain insecticides available specifically for aphids.

Grey cabbage aphid

Scientific name

Brevicoryne brassicae

Pest description

Grey cabbage aphids can be either wingless or winged. The wingless aphids are about 1.5-1.6 mm in length, greyish-green in colour, with the body covered in grey-white, mealy wax. This waxy substance is also secreted onto the plants. Winged aphids are slightly longer and slightly darker in colour than wingless aphids.

Host

All cruciferous crops

Damage symptoms

Grey cabbage aphids can become a serious pest on crops such as brussels sprouts, broccoli and cabbage, due to their ability to hide within plant leaves and florets. The first damage symptoms to appear are usually small bleached areas on the leaves, caused by the aphid piercing the plant tissue and sucking the sap from the plant. The leaves will turn yellow and appear distorted. This is where the aphids begin to colonise.

Serious infestations can significantly reduce crop yield, or the aphid can spoil the crop by leaving skin casts and a waxy substance on the plant, reducing the market value of the crop.

Life cycle

Aphids persist throughout the winter on cruciferous weeds, winter forage crops and brasscia crop residue. The population will increase significantly in the spring and large numbers of winged aphids are produced which rapidly spread to other cruciferous crops. In warmer periods, populations can double every few days. In cooler months, when plants are less palatable for aphids, there tends to be a natural population decline.

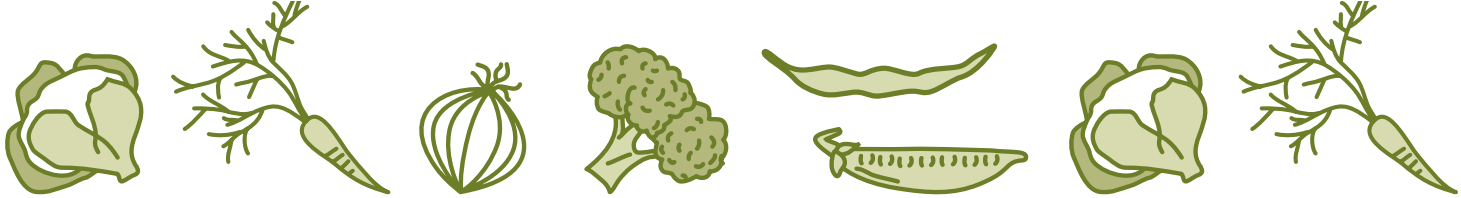
Management options

Cultural / Mechanical

- Cultivate or remove brassica crop residue soon after harvesting. The aphids may over-winter in the crop residue.
- Mulches of transparent or blue plastic placed on the soil between the rows may also reduce aphids from colonising.

Biological

- Weather is the most natural control agent. The cooler the conditions, the less likely aphid colonies will increase.
- Predators, such as hover flies, lace wings and ladybirds can substantially assist with reducing aphid numbers. Avoid synthetic pyrethroid sprays.



- Parasitoid wasps can attack aphid populations. The aphid will usually appear swollen and bronze coloured, with a small hole in its abdomen where the wasp has emerged.

Chemical

- As beneficial insects alone can significantly reduce aphid numbers, apply synthetic insecticides with caution so as not to harm the beneficials population. Monitor the status of beneficial numbers before applying any chemical. A yellow sticky trap can be a useful tool for this.
- There are certain insecticides available specifically for aphids.
- Crop scouting is essential. A threshold of 10-15% infected plants is an indication of when to spray. As the crop reaches its most critical time, the threshold would drop to about 10% of plants infected. About 4 weeks from harvest, the threshold may be 0%.
- Botanical extracts such as garlic and pyrethrin can be an alternative spray option.

Lucerne flea

Scientific name

Sminthurus viridis

Pest description

The adult Lucerne flea is a member of the springtail group. It is small, rounded, wingless and about 3 mm in length. It is yellow-green in colour and leaps into the air when disturbed. The eggs, although difficult to see, are pale yellow in colour and about 0.3 mm in diameter. The nymph (immature) growth stage emerges from the egg.

Host

Pasture and delicate seedlings like onions and poppies

Damage symptoms

Lucerne flea is more common as a pest in pasture, but can survive cultivation to attack crops that are planted following pasture or invade crop margins from adjoining pasture. The flea eats green foliage from the plant, leaving small holes which cause the plant to take on a speckled appearance.

Life cycle

The adult lays its eggs in the soil or on plant litter in clusters of about 50-60 eggs. Small nymphs emerge following cold, moist weather in the autumn and commence feeding on host plants such as clover and young onions. The nymphs remain in this immature state for about 4-6 weeks in the autumn and spring and up to 8-9 weeks in the cooler months. Lucerne flea population peaks in autumn through to winter. The population will start to decline when unfavourable weather conditions arrive. Flea numbers also decrease in the hot dry conditions of summer, but the eggs will survive.

Management options

Cultural

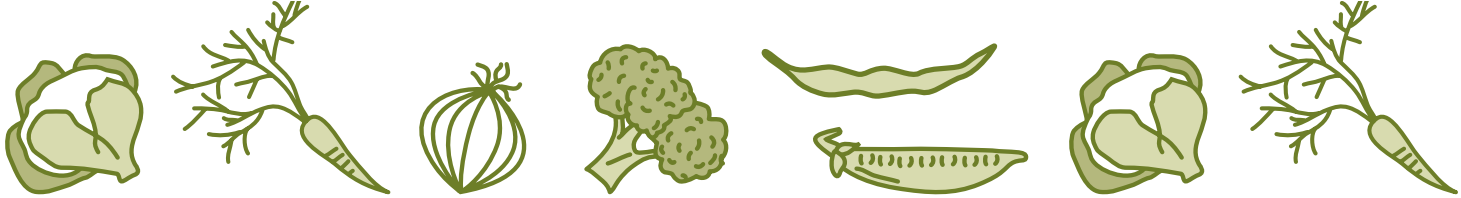
- Monitor infested pasture or crops following the autumn break.

Biological

- A predatory mite commonly called spiny snout (*Bdellodes lapidaria*) was introduced to Tasmania from Europe in 1985 to initiate a biological control program.

Chemical

- The most important time to apply spray is when all the nymphs have emerged from the eggs, but before they become adults. This is usually in the autumn, about 2-5 weeks following wet conditions.



Native budworm

Scientific name

Helicoverpa puntigera

Pest description

The adult moth reaches about 30-40 mm in length with the wings a reddish-brown tan colour. The caterpillars vary in colour throughout their six growth stages or instars. The young larvae are usually a light, creamy colour, and as they mature they take on a greenish-brown colour. The larvae have distinct dark, irregular lines down the body with small fine hairs protruding all over the body. The dome like eggs which protrude about 1.5 mm above the surface of the leaf, are white in colour and have a corrugated pattern. The eggs will gradually change colour, going from white to yellow to dark yellow with a distinct orange band at the head of the egg prior to hatching.

Host

Beans, broadbeans, brassicas, lettuce, peas, tomatoes, sweetcorn and poppies

Damage symptoms

The older caterpillars feed on pods, cobs and flowering parts of the crops and bore holes into the heads of crops such as sweet corn. The young caterpillars will tend to just feed on the surface of the terminal leaves. As they mature and increase in size, they will shift to the fruiting parts of the plant.

Life cycle

The adult moth is a strong flier, adapted to long distance emigration in spring and dispersing widely across areas where host plants are present and moving extremely long distances, eg. in strong northerly winds they can travel from inland SA, NSW and Victoria to Tasmania. Few individuals overwinter in Tasmania.

The female moth releases sex pheromones to attract male moths. The female will then lay eggs on the foliage of the plant host or certain weeds like storksbill (*Erodium)*. Eggs will usually hatch in 7-10 days at 18°C or 2-3 days at 25°C. The caterpillar will emerge and feed on tender foliage, or tunnel into small tender fruits such as seed capsules of storksbill and immediately hide in the plant from direct light. The caterpillars grow and moult through six growth stages or instars and will be 4-5 cm long at the final instar. The duration of instar development is influenced by diet and temperature. Once the caterpillars have finished feeding, they move from the plant to the soil, where they will bury themselves 5-10 cm below the surface. The caterpillars will change into copper-brown pupae for up to 21 days, depending on the temperature. *Helicoverpa* will rarely over-winter in Tasmania due to the cold winter months. It is known that strong northerly winds frequently bring them to Tasmania.

Management options

Cultural

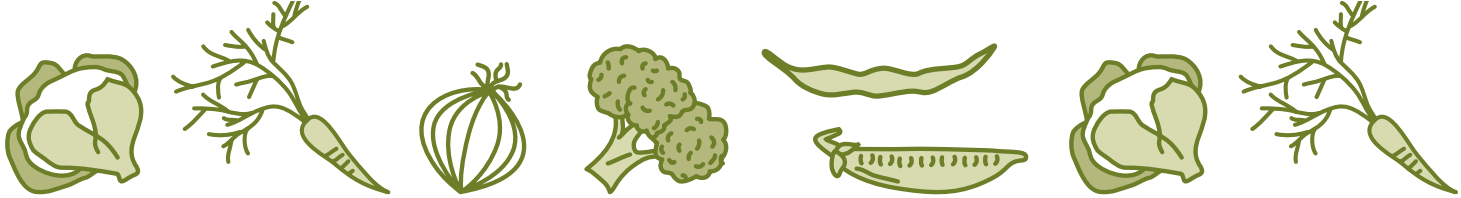
- Monitoring is an extremely important management tool to use. Look for eggs on the leaf surface of weeds such as storksbill (*Erodium*) and look for larvae feeding or small holes on pods where the grub may be boring. In some crops, such as corn, there is only a very short time window when the grub is exposed before it moves into the silks and then into the head.
- Pheromone traps should be used to monitor moth activity in the paddock.

Biological

- Predatory insects such as ladybirds, hover flies and lace wings assist with reducing pest numbers by feeding on small larvae and eggs.
- *Telenomus* and *Trichogramma*, parasitoid wasps of *Helicoverpa* can be effective if present in large numbers. Although these microscopic wasps are prevalent in other States, they have not been frequently encountered in Tasmania.
- The biological sprays, *Bacillus thuringiensis* (Bt) and NPV Gemstar are effective IPM control tools on young caterpillars when used in rotation with other management options.

Chemical

- Insecticides are effective, but resistance has built up in certain cropping areas of mainland Australia. Monitor before any insecticide application is applied.



Onion maggot (Seedling maggot)

Scientific name

Delia platura

Pest description

The adult growth stage of the onion maggot is grey in colour and looks similar to the common housefly. The maggot larvae are small, white and legless, reaching a length of 10 mm when mature. The maggot has distinct darkened feeding hooks at the feeding end. The eggs are small, white and elongate and are usually laid around the base of the onion plant. The pupae are brownish in colour, oval and about 5-10 mm long.

Host

Onions, beans and sweetcorn

Damage symptoms

In severe cases, young onion seedlings will wilt, with the onion collapsing just below the rotting stem of the seedling. The incidence of damage is usually patchy and slight. When the onion has reached the bulbing stage it becomes resistant to maggot feeding damage on the leafy tissue.

Life cycle

The adult fly lays its eggs on an onion crop at any stage of crop development, laying up to 200 eggs over a three or four day period. The larvae emerge from the eggs within 3-4 days and directly bore into the onion leaf tissue. They grow up to 10 mm long when mature. Once the larvae reaches maturity, it will fall from the onion and pupate in the soil. Onion maggots can over-winter on onion plant debris and in the soil.

Management options

Cultural

- Crop hygiene is crucial to prevent the pest from over-wintering.

Onion thrips

Scientific name

Thrips tabaci

Pest description

Thrips are small insects (1-2 mm long) that feed on the surface of plant tissues. They have sucking mouthparts which they use to extract nourishing plant sap from the surface cells of a leaf. Nymphs (the immature growth stage of the thrip) are smaller and wingless. Thrips disperse by flight and are carried by wind currents and movement of plant debris and farm machinery.

Host

Onion crops, but may also be found on a wide range of plants such as pyrethrum, potatoes and brassicas. Thrips thrive on fleshy green plants and will quickly move to neighbouring crops once the current host begins to desiccate. For example, thrips will thrive on fresh pyrethrum and potato plants, but once the plant begins to dry out, they will quickly move to the closest green crop.

Damage symptoms

Thrips leave tiny brown holes in the leaf surface and silvery patches, spots and streaks on the leaf as a result of the damage. In onions, most thrips are found between the leaves in the neck region. An infestation of thrips can stunt growth and significantly reduce yield. Young seedlings can be destroyed and seed viability can be reduced, but in most cases, a healthy plant can tolerate direct feeding damage.

Onion thrips can transmit Tomato Spotted Wilt Virus (TSWV) to lettuce plants, causing the plant to wilt and the leaves to develop a russeted appearance.

Life cycle

Adult thrips are golden brown and 1-2 mm long. Their lifecycle may be completed in 14-30 days in warm temperatures.

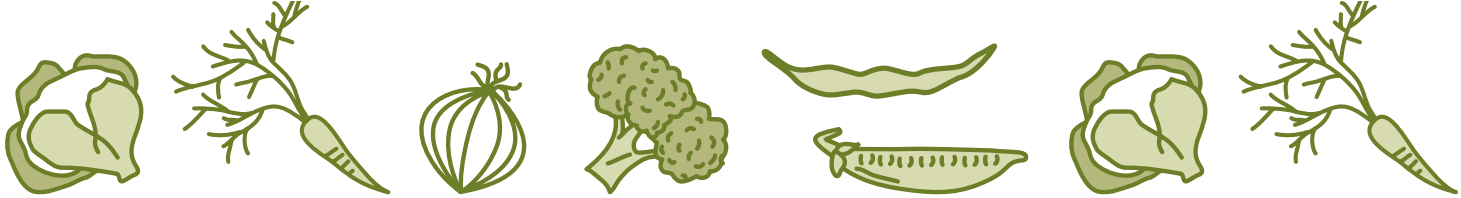
Female thrips lay tiny eggs on the plant tissue. Eggs hatch into tiny nymphs that feed on plant sap. The nymphs pass through three development stages, after which they drop to the soil and pass through the pupal stages (the lifecycle stages prior to appearing as adults). Thrips will then emerge as adults and fly to the plant.

The eggs and pupal stages are not killed by insecticides.

Management options

Cultural

- Heavily infested plants should be removed from the paddock and buried. Intercropping of onions and carrots has been shown to reduce thrip populations.



Biological

- Natural enemies of thrips include predacious mites and lacewings. However, these beneficials are extremely vulnerable to insecticides and may not survive in sufficient numbers where insecticides have been used.

Chemical

- Whilst insecticides can be used to control thrips, they may not be the most effective control due to increasing resistance problems. Successful management of thrips using insecticides can be difficult because plant parts, such as the leaves of the onion neck, often surround and protect them from spray. The result can be a waste of chemicals, time and money. If insecticides are used, thorough coverage of the plant is needed, along with rotation of chemicals from different chemical families to reduce the risk of developing resistance.

Potato moth

Scientific name

Phthorimaea operculella

Pest description

The adult potato moth is about 8 mm long and silver-grey in colour with small black markings on its wings. The moth is most active at nightfall, but can be seen flying in potato crops and crops where volunteer potatoes are growing during the day.

The eggs are oval shaped and are laid singly on the underside of potato leaves or, more damagingly, on tubers exposed to the air. The eggs are white and change to yellow prior to hatching. The caterpillars are about 12 mm long at maturity, and grow through four stages or instars before maturity. The young caterpillars are grey or yellow-white in colour and as they mature will have a pink or grey tinge. The head capsule is small and brown. The pupae are formed in a silken cocoon, which is enveloped in plant material, soil particles or in storage to provide camouflage from predators.

Host

Potato tubers and foliage

Damage symptoms

The potato tuber and foliage can experience a significant amount of damage from the potato moth caterpillar. The leaf will develop blister like symptoms and may curl at the ends, however it is rare to find leaf damage of consequence in Tasmanian potato crops. Leaf damage is much more common in volunteer potatoes especially if water stressed. The damage may kill the plant in severe cases. The caterpillars can also feed on the tubers in the field and in storage, causing thin, dirty looking tunnels in the tuber, with clusters of excretions from the larvae around the entrance of the tunnels.

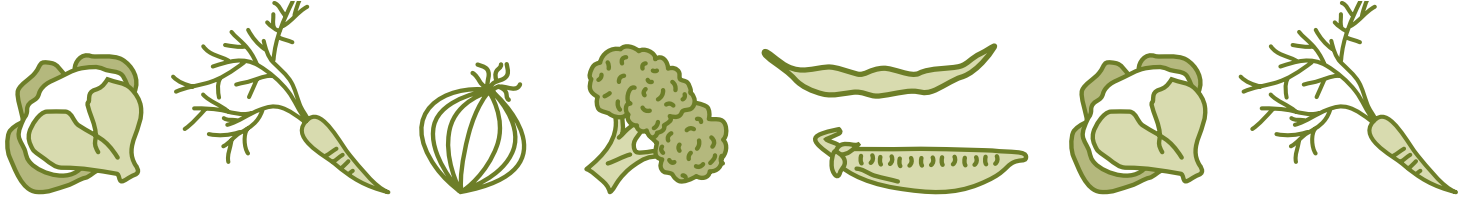
Life cycle

In Tasmania, the potato moth can go through 3 generations per year with all life stages continuing to develop very slowly throughout the winter in cold coastal districts. All stages of the life cycles can be present during the warmer months. Once the egg has been laid, hatching may occur within 5-30 days, depending on temperature. The larvae will then carry on through four growth stages before reaching maturity. In Tasmania, the main over-wintering population first emerges in early December, with two or more peaks in flight activity in February and April. The population crashes once the autumn rains occur in April-May.

Management options

Cultural/Mechanical

- Irrigate paddocks after top die off to maintain soil moisture and prevent the ground from cracking. This prevents the larvae entering the soil and attacking the tubers. All tubers should be removed from the paddock following harvest. This will prevent any over-wintering on re-growth plants the following season.



Biological

- Three parasitoid wasps (*Apanteles subandinus, Orgilus lepidus* and *Copidosoma koehleri*) have been introduced to potato districts in Tasmania and are effective at reducing moth populations. However, insecticides will reduce the wasp population.

Chemical

- Insecticides are only effective against caterpillars feeding on the foliage, not against caterpillars feeding on potato tubers. Cool storage of the tubers will minimise any further feeding damage.

Red-legged earth mite

Scientific name

Halotydeus destructor

Pest description

Red-legged earth mites (RLEM) are about 1 mm long and have a black body and eight legs that are a distinct orange-red colour. The mouth is also orange-red in colour.

The eggs are usually laid in small clusters and are yellow-orange in colour. The nymphs, or young mites, emerge with six red legs and a pale body colour. As the nymphs mature into adults, they grow another two legs.

Host

Onions, brassicas, peas, potatoes, lettuce, poppies and clover

Damage symptoms

The mites tend to feed on the cotyledon and leaves of seedlings, causing distinct silvering, whitening and bleaching on the leaves. They lacerate the leaves and then suck the sap from the plant. In heavily infested areas, the plant may show signs of distortion and may eventually die.

Life cycle

The RLEM arises primarily in pasture. It will go through several generations each year and will often over-summer as eggs when conditions are too warm. The eggs that over-summer are usually found in the dried out body of the female mite. The eggs will hatch when conditions become cooler. The eggs are usually laid on plant debris or in the soil when conditions are cool and suitable for egg laying.

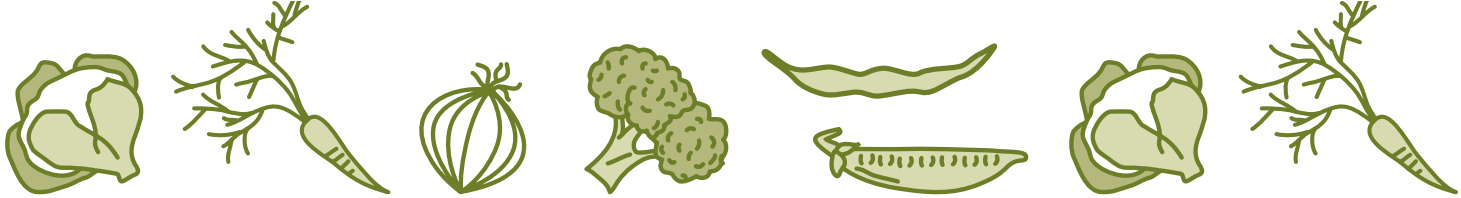
Management options

Cultural

- Remove crop re-growth and host weeds such as clover, capeweed and thistle to reduce the food source. Seedlings should be monitored, particularly around the base of the plant, along with weedy fence lines and adjacent pasture paddocks.
- Prefers well drained soils, especially coastal districts.

Chemical

- Treat seeds with insecticide prior to sowing. Spot spray ‘hot spot’ areas. All insecticides should be applied in late afternoon and early morning when the pest is actively feeding.



Rutherglen bug

Scientific name

Nysius vinitor

Pest description

The adults grow to about 5 mm long, the male being slightly smaller than the female. They are grey-brown in colour with silver wings. The nymphs are smaller, wingless and red-brown in colour. They feed mainly on the sap of newly emerged plants and seed heads.

Host

Most vegetable crops

Damage symptoms

Rutherglen bugs feed on seed heads of weeds and gradually migrate to nearby crops such as potatoes and other crops. They are usually present in clusters on the plant shoots and stems, sucking the sap from the plant. Damage symptoms such as plant wilting occur rapidly once the bug commences feeding.

Life cycle

The female will lay up to 400 eggs through the spring. The eggs are usually laid in small clusters on weeds or on the ground. The eggs are about 1 mm long and are an off white colour, becoming yellowish-brown close to hatching.

The nymphs, or young bugs, emerge and go through five growth stages or instars before reaching full adult size. The young are yellowish-brown in colour, gradually becoming darker towards the end of the fifth growth stage. Wings will appear during the fourth growth stage. The Rutherglen bug can over-winter on sheltered weeds.

Management options

Cultural/Mechanical

- Rainfall and irrigation can reduce numbers in highly populated areas.
- Ploughing weeds prior to a spring infestation will remove many young and adults from the soil.

Chemical

- Insecticides will provide short-term control if the bug is present in large numbers. The adults are strong walkers and can reinfest a crop following spraying. Sprays should be applied when the bug is most active, such as during warmer days.

Slugs

Scientific name

Deroceras

Pest description

Slugs resemble snails in general appearance except the shell is absent. The body is broad and elongated, usually light grey in colour, with two tentacles on the head. Slugs move by producing a clear, silvery mucus which is produced from glands on the underside of the body.

Host

Brasscias, peas, potatoes, beans, pyrethrum and poppies

Damage symptoms

Slugs can cause considerable damage to plant foliage, especially when conditions are wet. Slugs feed on the foliage leaving extensive holes in the plant. Damage is not usually uniform across the crop. Crop edges that are usually moist are prime damage areas. Contamination by slugs can often cause problems in frozen produce.

Life cycle

The slug lifecycle is influenced by conditions that are favourable to breeding and feeding. Slugs are dependant on wet, moist conditions and will not survive in very dry conditions. Slugs can take 1-2 years to reach maturity, with the adult capable of living for a few months or even years.

Eggs are spherical and white-yellow in colour and are laid in clusters in decaying plant material and moist soil. Eggs hatch within 2-4 weeks and small off-white to grey slugs emerge. Slugs over-winter either as eggs or as adults either in an active feeding state or a non-feeding dormant state.

Slugs can shelter from predators in cracks in the soil and hence can develop broad acre populations whereas snails require surface shelter such as weeds, sticks, stones and hence, tend to prefer paddock edges.

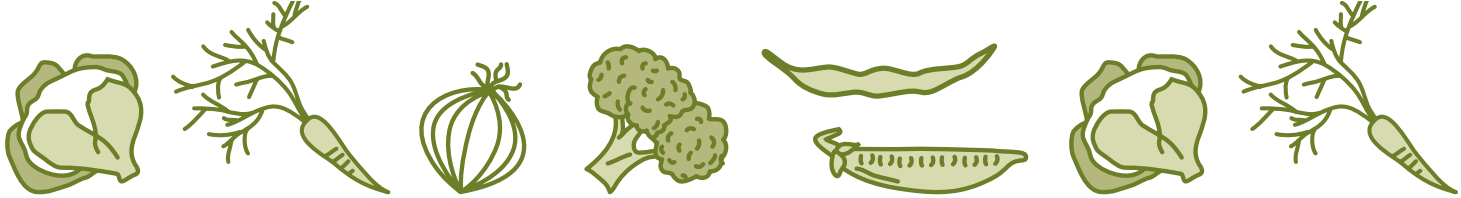
Management options

Cultural

- Any form of barrier that is rough, such as mulches, bark, etc. will deter slugs, as they prefer smoother surfaces to move on.
- Soil cultivation can reduce slug pressure.

Chemical

- Slug pellets can be an effective control method. As slugs generally affect the crop edges, placing the pellets around the paddock prior to planting will deter slugs from entering once it has been planted.



Springtails

Scientific name

Onychiurus

Pest description

Springtails are wingless insects with a body that is usually covered in minute hairs or scales.

Host

Peas and poppies

Damage symptoms

Springtails are primarily scavengers, feeding on fungal hyphae and rarely cause significant damage. If conditions are extremely favourable, they can cause damage to the seeds, seedling shoots and foliage of a wide range of plants.

Springtails have chewing mouthparts and are usually found in large numbers chewing parts of the plant that are already rotting or infected from either disease or plant damage.

Life cycle

Springtails go through several generations per year, with no metamorphosis occurring. Females lay tiny eggs in small clusters around the feeding area or within the soil. The young emerge taking on an adult-like form, but will fully mature by going through a series of moults.

Springtails can spread by several methods such as floating on moving water (eg. streams, rivers and drains), the movement of crop residue or soil and by crawling. Springtails favour cool, moist conditions. Crop waste and other decaying organic matter provides ideal conditions for survival and reproduction. They seem to become more abundant following rain or irrigation. Springtails naturally decline during the warmer, drier months.

Management options

Cultural/Mechanical

- Liming and cultivation of the soil prior to planting will reduce the population in the soil.

Chemical

- Insecticides should only be applied when correct diagnosis has been made and damage to seedlings is severe enough to warrant spraying.

Whitefringed weevil

Scientific name

Naupactus spp

Pest description

The adult weevil is wingless, with distinct white stripes along its grey back. The larvae are creamy-white in colour, legless and grow up to 12 mm in length.

Host

Onions, potatoes, beans, brassicas, lettuce, lucerne and broad leafed weeds

Damage symptoms

The larvae live in the soil, burrowing into the roots of plants and tubers of potatoes. In pastures, the larvae feed on tap rooted, broad-leaf weeds and clovers. The weevil favours lucerne, and crops planted following lucerne are more susceptible to damage. Most damage is caused in spring and summer when the larvae are fully grown and are feeding most actively. Circles of damage reflect the point source origin.

Life cycle

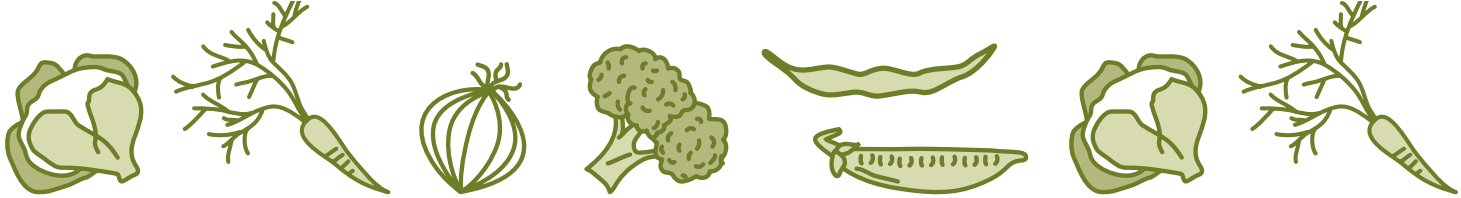
The life cycle takes two years to complete and spreads slowly from point sources. The adult weevil lays single spherical eggs (0.5 mm) that are usually found on the stems, low growing foliage and in the soil. As the egg matures, it changes from white to yellow and then grey-black prior to hatching. The female is capable of laying about 10 eggs a day if fed on a favoured host like lucerne.

The larvae hatch in autumn and grow from about 1.5 mm to 14 mm in length in four growth stages (instars). They grow for twelve or more months to reach full size. The mature larvae commences the pupal stage by burrowing just below the soil surface to form the pupae. The pupae are long, pale yellow and gradually change to dark brown before the adult weevil emerges.

Management options

Cultural

- Remove and control volunteer hosts as they provide refuge for the insect and allow it to spread to nearby crops.
- Grow winter cereal crops, which are not susceptible to weevil damage. This will reduce numbers and prevent an outbreak in the following vegetable crop.
- Rotate favourable hosts (onions, brasscias, potatoes, peas, beans, lucerne) with unfavourable hosts (grasses and cereals) to reduce the risk of increasing populations.
- Soil cultivation and fallow periods will reduce populations but may need to be supplemented with fumigation in heavy infestations.



Chemical

- Soil fumigation may be required if the population is high. Insecticides should be incorporated into the crop at the time of sowing.

Wingless grasshopper

Scientific name

Phaulacridium vittatum

Pest description

The adult grasshopper is usually greyish-brown in colour but can vary slightly depending on the food it is eating. They grow 12-20 mm long, with the male usually slightly smaller than the female. Most of the grasshoppers have small short and pointed wings that are non-functional for flying, although about 10 percent of adults have full wings and can fly.

Host

Broad leafed plants including potatoes, fruit trees and weeds

Damage symptoms

The grasshopper feeds on plant foliage, and in severe cases they can totally defoliate the plant. The leaves will show signs of being chewed.

Life cycle

The adult grasshopper completes one lifecycle a year. It lays its eggs in fallow or bare soil, especially in light soils. The young grasshopper will emerge in November and develops through five nymphal stages (instars) before becoming an adult. The adult disperses from egg bed areas in December-January. Egg beds are sandy clearings in woodlands on the edges of paddocks or sheep camps on bare ridges. Temperature determines the rate of development. In spring, it can take 7-10 weeks to reach maturity. Peak activity usually occurs from January through to March.

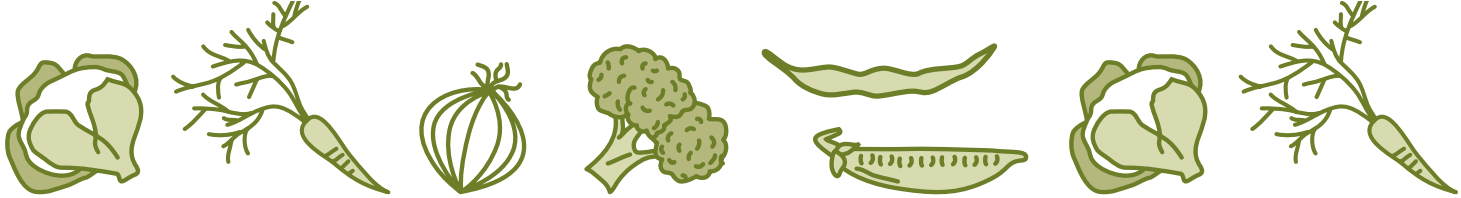
Management options

Cultural

- Regular crop inspections for signs of the grasshopper and for the damage symptoms.

Chemical

- Insecticides may be required if an outbreak occurs. This is most effective if it is possible to pinpoint juveniles at or near egg-bed sites. This requires monitoring of egg beds.



Wireworm

Scientific name

Elateridae

Pest description

Wireworms are the larval stage of the common click beetle. The beetle itself is not the pest. It is the larvae that causes the damage. The adults are black to brown in colour and grow up to 12 mm long. The larvae are thin, yellow to brown in colour, with a smooth segmented body reaching about 25 mm long when fully grown. The feeding appendages on the larvae are dark brown in colour with distinct powerful biting mouthparts.

Wireworm populations tend to increase in paddocks that were previously under pasture for two or more years. Following cultivation, populations will decrease, but many can survive and cause considerable damage for three to five years.

Host

Vegetable seedlings, root and tuber crops

Damage symptoms

Wireworms feed most actively in the spring, which coincides with the planting of crops. The worm can cause the plant to die by chewing into the germinating seed or underground stems. In potatoes, the worm burrows deep into the tuber forming small round holes which affect the quality of the crop.

Life cycle

The adult click beetles mate during the spring months. Eggs are then laid just below the soil surface, either singly or in small clusters, and usually in pasture crops or very weedy areas. The eggs will hatch and small off-white larvae about 2 mm long appear. The larvae remain active, feeding on plant tissue and crops, for 3-5 years. They then mature and burrow deep into the soil to pupate in the winter months. The adult over-winters in the pupal stage, and emerges the following spring or when the soil is disturbed.

Management options

Wireworm control is mostly preventative. Once populations have established in the soil, it is almost impossible to use an insecticide effectively, as they burrow beneath the soil and are able to avoid exposure to chemical applications.

Cultural/Mechanical

- Soil cultivation prior to planting will help reduce wireworm numbers by desiccating the larvae and exposing the eggs. If populations are high, then leaving the paddock fallow prior to sowing can significantly reduce numbers.

Chemical

- Certain insecticides are registered, and if used, should be applied at planting. As mentioned previously, it is difficult to achieve control with chemicals once the pest has established.

Appendix F - Farm hygiene guidelines

farm hygiene
protecting our future

On-farm guidelines

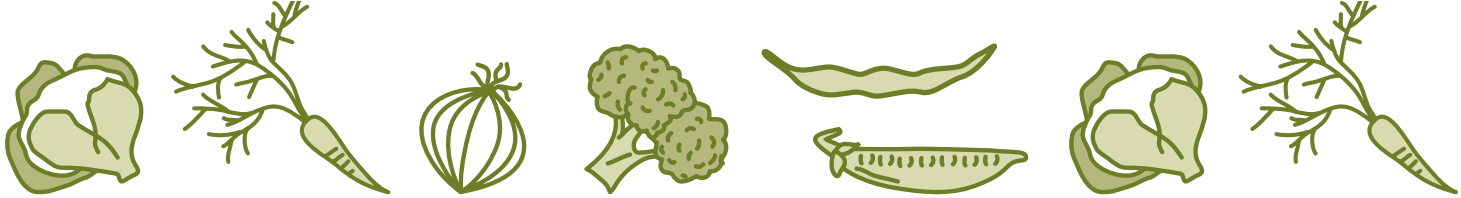
It is dangerous to assume that special hygiene precautions aren't needed just because a problem isn't obvious! As a land owner making a living from your farm, it is up to you to protect it and your future against weeds and plant and animal pests and diseases, that may arrive with machines, people, plants and stock. Enforcing these guidelines is the simplest way of protecting your future.

Clean on:

- Make it known that all machinery, bins and boxes coming onto your property must be clean. This includes delivery trucks, contract planters, harvesters and sprayers or borrowed equipment.
- Turn away anything that is not clean.
- Tell crop advisers and field officers that their vehicles, boots and hand tools must be clean on arrival.

Clean off:

- Tell contractors in advance that machinery must be as clean as practicable of dirt before it leaves the paddock.
- Supply a hard surface washing area with a pump and a hose of at least 25 mm diameter (with pressure nozzle) for cleaning all equipment before it leaves your property.
- Make it easy for visitors (other farmers, advisers, groups) to clean boots and equipment before they leave.
- All visiting vehicles should stay on tracks or grassed headlands and not be driven onto the paddock.
- Buy disease free certified or accredited stock, seed, etc.
- Isolate all incoming stock until they have been checked for diseases and treated.
- Put up a farm hygiene sign to tell visitors what is expected of them.
- Expect your staff and family to be as farm hygiene conscious as you are.



farm hygiene
protecting our future

farm visitor guidelines

It is dangerous to assume that special hygiene precautions aren't needed just because a problem isn't obvious! As a visitor to rural properties, you have the responsibility of not introducing weeds, diseases or pests, of plants or animals onto any property. These guidelines apply to all farm visitors, but particularly to those who regularly move between properties.

- All visiting vehicles, machinery, footwear and hand tools must be clean on arrival.
- Visiting vehicles should not be driven onto the paddock but stay on tracks or grassed headlands unless permission is obtained from the owner.
- Regular visitors should carry and use the footwear washing kit (a container of clean water, basin, scrubbing brush and scraper) and use it to clean footwear and hand tools before leaving the property. The proper washing process is to Scrape, Wet, Scrub and Rinse. Washing water must be disposed of safely.
- Casual visitors should make use of property facilities to wash down boots and implements before leaving the property.
- Agricultural machinery, plant and equipment should be scraped clean of most soil in the paddock and washed down before being moved to a new work site. The land owner is the best person to tell you where this can be done.
- Clean overalls should be worn, particularly when handling animals.
- All practical measures should be taken to reduce risks of spread of infections, soil borne diseases and weeds when moving livestock around and between properties.
- Ask the land owner about any contaminated areas (weeds, diseases) on a property that should be avoided or where precautions can be taken to prevent spread to clean areas.

Appendix G - Further reading and references

IPM Websites

- www.gov.on.ca/OMAFRA/english/crops/facts/IWM.htm
- http://cipm.ncsu/index.html
- Radcliffe's IPM World Textbook - www.ipmworld.umn.edu
- Internet IPM Resources Australian - www.ippc.orst.edu/cicp/australia.htm
- Traditional Practices for Plant Disease Management in Traditional Farming Systems - www.tropag-fieldtrip.cornell.edu/thurston_TA/default.html
- www.weeds.org.au
- www.ahr.com.au - Cover cropping
- Bugs for Bugs - www.bugsforbugs.com.au
- Beneficial Bug Co. - www.beneficialbugs.com.au
- Bioresources Pty Ltd - www.bioresources.com.au
- EcoGrow Australia Pty Ltd - www.ecogrow.com.au
- www.goodbugs.org.au
- www.sarep.ucdavis.edu

Government Websites

- www.dpiwe.tas.gov.au
- www.agric.nsw.gov.au/
- www.dpi.qld.gov.au/
- www.pir.sa.gov.au/
- www.nt.gov.au/dpif/
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- Ransom, Lois. Vegetable Disease Handbook, 1992 Department of Primary Industries, Devonport.
- What Garden Pest or Disease is That? 1985. Judy McMaugh. Landsdowe Press Australia. ISBN 0-7018-1932-4
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- Sindel, B.M. (2000) - Editor. Australian Weed Management Systems. RG & FJ Richardson, Melbourne. ISBN 0-9587-4394-0