# A Field Guide to INSECTS AND DISEASES OF Australian POTATO CROPS

PAUL HORNE, RUDOLF DE BOER AND DENIS CRAWFORD

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# Contents

# Beneficial Insects

The beneficial insects referred to in this book are those that attack and kill pests. There are many other types of beneficial insects, such as pollinators, decomposers and weed eaters. Almost all are native to Australia.

The two main types of beneficial insects are predators and parasites. Predators are free-living individuals that attack and eat their prey (for example, carnivorous mammals eat larger prey). Parasites, on the other hand, survive attached to or inside their prey and feed off the live host (for example, leeches and tape-worms attack mammals).

Predators often eat a range of prey, not just one species. General predators will attack just about anything that is the right size so long as their jaws can manipulate it. If food is scarce many predators can also be cannibalistic, eating smaller members of their own species. Parasites are usually far more specific and may attack only a particular life-stage (for example, the egg) of a single species.

## *APHIDIUS* WASPS

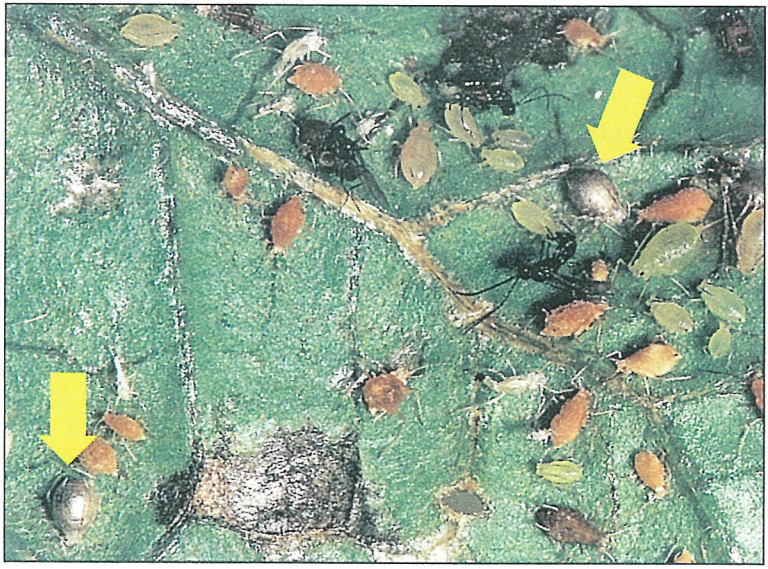
Several species of *Aphidius* wasps are common in potatoes.

- The adult wasps are tiny (2 to 3mm long) and have a very constricted waist and thin abdomen.
- The 'mummies' are more easily seen. These are the shells that were once aphids but have been transformed into cases containing the immature stages of the wasp.
- Mummies are usually very round, almost spherical, and a bronze-gold colour.
- If the adult wasp has emerged from its host, then a neat round hole can be seen in the mummy.

### Pests attacked

- The wasps only attack aphids.
- They are present wherever aphids are found: in crops, weeds and garden plants (especially roses).

Aphidius wasps stinging aphids. Note the silver 'mummies' of parasitised aphids. The orange-coloured aphids have fungal infection.



Brown lacewing adult.

## BROWN LACEWINGS

- Adult native brown lacewings (*Micromus tasmaniae*) have delicate, lacy brown wings and are about 10 mm long.
- The immature stages (larvae) look completely different to the adults. The larvae have long, thin bodies with prominent jaws at the front of their head.
- They have cream-coloured eggs which they lay singly on the underside of leaves. The eggs are laid flat on the leaf, not on a stalk as does the green lacewing.

### Pests attacked

- The favourite food of lacewings is aphids, but they will feed on just about any insect that is an acceptable size. The larvae are the main predators but the adults also eat insects, especially eggs.
- Larvae eat their prey through curved, hollow jaws, and essentially suck out the body contents of their prey. Larvae can eat between 100 and 200 aphids each in their short lives.

## DAMSEL BUGS

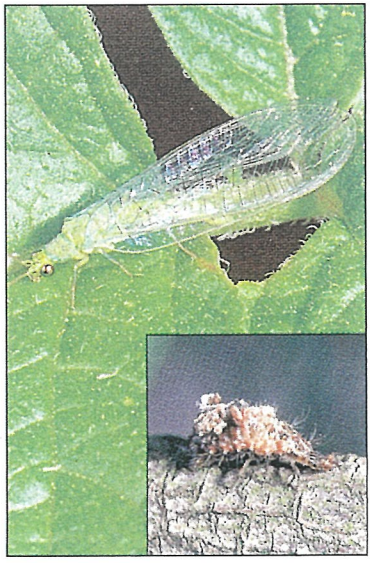
- These true bugs (*Nabis kinsbergii*) are voracious predators that kill prey by stabbing them with their curved mouthparts, then sucking up the contents of the unfortunate victim.
- They are slender, pencil-shaped insects and the immature nymphs look like smaller versions of the adult. The adults have wings (which the immature stages lack) that are folded along the body. All stages have a grey-brown colour.

### Pests attacked

- Damsel bugs prefer to eat soft-bodied prey such as eggs of the caterpillar pests (potato moth, loopers, *Helicoverpa*) and will also attack and kill caterpillars up

Damsel bug.

Green lacewing adult; (inset) immature green lacewing.



to the medium-sized *Helicoverpa*. In addition to caterpillars, they will also eat aphids and leafhopper nymphs.

- They occur in a wide range of crops and usually appear when potato crops are about half-way through their growing life.
- In years of very high potato moth infestation, damsel bugs are also present in high numbers as they take advantage of the food source (the pest).

## GREEN LACEWINGS

- The common Australian species is *Mallada signatus*. Although *M. signatus* is available from an insectary, it is also commonly found in potato and other crops.
- The green lacewing adults, like brown lacewings, have delicate, lacy wings but are larger (often 20 mm or more long) and are bright green.
- They fly at night and have very golden eyes.
- The immature stages have spines on their backs, with which they impale the carcases of some of their previous prey.
- The eggs are laid on stalks, often in groups. When freshly laid the eggs are a pale green, when about to hatch they are grey, and when they have hatched they are white.

### Pests attacked

- Immature green lacewings are general predators, but the adults are not predatory (unlike brown lacewings).
- The immature stages eat a wide variety of prey, sucking up the body contents with their hollow jaws.
- They will eat eggs, young caterpillars and aphids. If insufficient food is present, they will be cannibalistic, with larger individuals eating smaller ones.

Hoverfly adult.

## HOVERFLIES AND TACHINID FLIES

- Adult hoverflies are recognisable by their habit of hovering over plants, and particularly flowers.
- The adult flies have a yellow and black spotted abdomen, which makes them look rather like wasps and bees.
- The immature stages of hoverflies are legless maggots, that can climb in the foliage of plants. The maggots look like flattened caterpillars with wavy sides.
- Tachinid flies include species that are very large and metallic green, while others are small brown and black flies with stout bristles on the abdomen.
- The egg stage is the most commonly found evidence that tachinid flies are present. The eggs are shiny black specks or oval white balls usually attached just behind the head of caterpillars.

The bristles of a typical Tachinid fly.

- The larval stages are not visible as they develop inside the host.

**Pests attacked**

- Hoverfly maggots are usually found in aphid colonies, since they eat aphids.
- All tachinid flies are parasitic in the immature stages, and they attack many pest species including *Helicoverpa* and looper caterpillars.
- Hoverflies develop rapidly at temperatures averaging 25°C, taking about three weeks to grow from egg to adult.

Recent Australian studies have shown that hoverfly larvae each consume several hundred aphids as they develop. The adult hoverflies do not feed on aphids.

Two-spotted ladybird.

Common spotted ladybird.

## LADYBIRD BEETLES

- Three predatory species which occur in potato crops are the transverse ladybird (*Coccinella transversalis*), the common spotted ladybird (*Harmonia conformis*) and the minute two-spotted ladybird (*Diomus nitescens*).
- The common spotted ladybird is the largest, and is orange with black spots. The transverse ladybird can be orange or red with black blotches rather than spots. The minute two-spotted ladybird is a very small black ladybird with two orange-red spots.
- The eggs of the two larger species are yellow, and laid in closely packed batches. The number in each batch varies, but often twenty eggs are laid together. Just before the larvae hatch, the eggs darken to grey then black.
- Larvae look completely different to the adults. Larvae of the two larger species are mostly black, soft-bodied with yellow-orange spots on their backs. Larvae

Transverse ladybird.

of the minute two-spotted ladybird are a grey-brown colour with a fringe of soft spines.

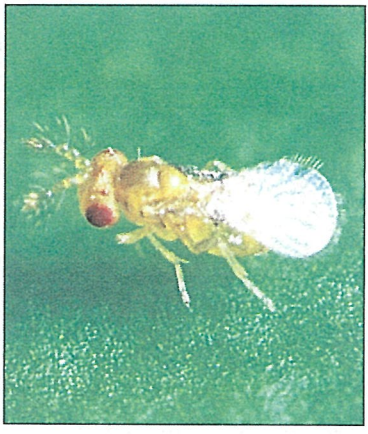
### Pests attacked

- The larger species of ladybirds are general predators that prefer aphids but will eat other pests such as small caterpillars and eggs. The minute two-spotted lady-bird is mainly known as a predator of mites.
- Both adults and larvae are predators.

## *ORGILUS, COPIDOSOMA, APANTELES* AND *TRICHOGRAMMA* WASPS

- Among the more common species in potatoes are *Orgilus lepidus*, *Copidosoma* species, *Apanteles subandinus* and *Trichogramma* species.
- *Orgilus* is the largest (the female is about 12 mm long including the stinger), and is mostly black but has a red mid-section to its body.

*Orgilus* sp. stinging potato moth larva in a leaf mine.



*Trichogramma carverae*.

- *Apanteles* is a little smaller (about 7 mm long), all black, and the females have a much shorter stinger than *Orgilus*.
- *Copidosoma* wasps are much smaller, about 1 mm long and all black.
- *Trichogramma* wasps are tiny and are unlikely to be seen in potato crops even when present, as each wasp is less than 0.5 mm long.
- The immature (larval) stages of all these wasps are as internal parasites, hidden in the bodies of their hosts.
- *Orgilus* and *Apanteles* take over the host at the pupal stage and spin a cocoon. This cocoon can be seen easily, unlike the larval stages.
- *Copidosoma* turns its host into a 'mummy' consisting of many cells, each containing a *Copidosoma* pupa. The mummy changes from yellow to black as the pupae develop. The wasps in each mummy have a fairly synchronised emergence.
- Eggs parasitised by *Trichogramma* turn black before the adult wasp emerges.

## Pests attacked

- All of these wasps can attack potato moth, but *Trichogramma* will also attack eggs of other pest caterpillar species such as *Helicoverpa*, loopers and cluster caterpillar.
- The potato moth parasites *Orgilus lepidus*, *Apanteles subandinus* and *Copidosoma* species are biological control agents deliberately introduced into Australia in an attempt at classical biological control. They only attack potato moth.
- *Trichogramma* attack the hosts' egg and kill it in the egg stage. That is, no caterpillars develop from parasitised eggs.
- *Copidosoma* also attack the egg of the host, but the host is not killed until it is quite a large caterpillar.
- *Orgilus* and *Apanteles* attack caterpillars, and prefer to attack very young caterpillars. They then kill the host when it is ready to pupate.

Typical 'mummies' of *Copidosoma*.

Male (left) and female (right) red and blue beetles.

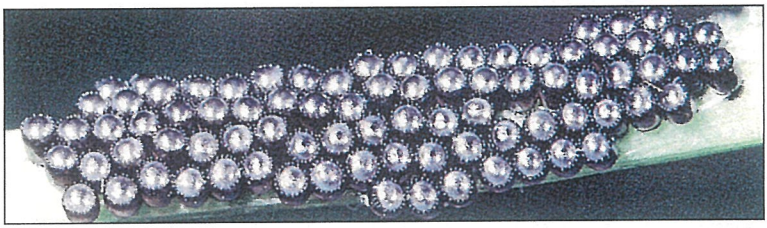
## RED AND BLUE BEETLES

- This beetle (*Dicranolaius bellulus*) is red and blue. It is a small (8 mm long), shiny beetle and the male has one enlarged segment in the antennae. It is very active both in the foliage and on the soil of potato crops, but runs and walks rather than flies.
- The immature stages are not usually noticed in potato crops, but the eggs are bright yellow and the larvae are orange. They are found in the soil rather than in the foliage.

### Pests attacked

- The adult beetles are predatory and scavenging, and will eat a variety of live prey and dead insects. They are fairly small and prefer small food such as moth eggs (*Helicoverpa*, loopers, potato moth) and very young caterpillars.

Adult shield bug.



Typical shield bug egg raft

## SHIELD BUGS

- The shield bug (*Oechalia schellenbergii*) is similar to the damsel bug in that it is true bug with sucking mouth-parts.
- The adult shield bug is easily recognised by the large spikes behind the head (its 'shoulders').
- The immature nymphs have bright red marks on their backs that are not visible on the adult. They are larger and more stout than damsel bugs. Shield bugs are also known as stink bugs.
- The shield bug eggs are laid in closely packed batches, and are a metallic, black colour with white spines around the rim of each egg. They are usually laid in multiples of fourteen on potato leaves.
- A closely related species also found in potato crops is the glossy shield bug (*Cermatulus nasalis*), so called because the immature stages are very shiny red

and brown-black. Adults are similar to the predatory shield bug without the spikes behind the head.

- Glossy shield bug eggs are also metallic coloured with white spines. They are usually laid in batches of fifty and have short white spines.

### Pests attacked

- These two predatory shield bugs appear to feed preferentially on the larger species of caterpillars, such as loopers and *Helicoverpa*, but they will eat a range of species and will attack all stages of caterpillars.

## SPIDERS

- Spiders are invertebrates with eight legs, and the body is divided into two sections giving a distinct 'waist'. They differ from insects, which have six legs and three body sections, and mites which have eight legs but only one body section (no 'waist').
- Among the spiders found in potato crops are wolf spiders, jumping spiders, crab spiders, lynx spiders, and many web-spinning species. Wolf spiders are common on the ground level of potato crops. They usually have strong white markings on their backs. Many different species of web-spinning spiders, crab spiders and jumping spiders are common in the foliage.
- Nearly all spiders are venomous, as this is how they subdue their prey, but not all are poisonous to humans. They are all predatory, and can be regarded as being beneficial.

### Pests attacked

- Not all spiders spin webs to capture their food. Some spiders chase and kill their prey (wolf spiders),

A wolf spider.

others ambush or leap on their prey (jumping spiders and lynx spiders) while others capture their food in webs. Many spiders will only attack moving prey.

- The pests that are attacked differ according to the species of spiders. Most are general predators and will attack caterpillars and bugs. Those catching food in webs will eat almost anything so long as it is the appropriate size.
- Spiders often produce white egg sacs which they carry around or fix to plants.
- Some spiders (such as wolf spiders) care for their young after they have hatched, and the parent may carry fifty or so spiderlings on its back.

# Pest Insects

Pests cause damage to leaves or tubers, or may introduce diseases. Soil pests (for example, wireworms and whitefringed weevil) that cause direct damage are often in the ground when the crop is planted, while foliar pests (for example, loopers and aphids) invade the crop. Pests such as potato moth invade the crop and may move from foliage to tubers.

Insects that carry disease are referred to as vectors of that disease. Aphids, thrips and leafhoppers can carry some potato diseases, but it is very important to note that disease is not necessarily present simply because aphids, thrips or leafhoppers are found in a crop. Firstly, only certain species of these insects are vectors of diseases, and secondly, even if the vector is present, there must also be a source of disease. Any assessment of the risk of disease in the crop must include potential sources of virus disease and not just recognition of the presence of vectors.

Distinguishing between species of tiny insects, including their different life-stages, requires careful examination, usually with a microscope. Some descriptions are given here, but more detailed guides are available.

For many years, control of insect pests has relied

on routine applications of insecticides. A slightly improved control strategy involves monitoring pest numbers and applying insecticides at a predetermined level (threshold). However, a far better option is to also monitor how many beneficial insects are present compared with the number of pests present. It is the changing ratio of pests to beneficial insects that will tell you the risk of damage in any particular crop.

## AFRICAN BLACK BEETLES AND COCKCHAFER GRUBS

- Both African black beetles (*Heteronychus arator*) and cockchafer grubs (many species) are beetles called scarab beetles. This group also includes the highly beneficial dung beetles.

African black beetle.

Cockchafer grubs and damage.

- The immature stages of the pest scarabs are C-shaped grubs (sometimes called curl-grubs or white-grubs).
- They have a distinct head and legs, and also usually a swollen, dark tip to the abdomen. The colour of the head is an important feature in helping to identify the species of cockchafer present.
- Adult African black beetles are very shiny black beetles, about 10 to12 mm long, and their front legs are modified for digging. The adults of other cockchafers have the same general body shape but different species have various sizes and colours. The African black beetle is a pest accidentally introduced from southern Africa, but the other cockchafers that are potato pests are native to Australia.

### Damage

- African black beetle adults and larvae can cause damage to potatoes, but most cockchafers cause damage only to tubers.
- Adult African black beetles can kill potato plants by feeding on the stems just below the soil surface. The stems are shredded or broken, and so the top of the plant dies. Larval stages damage tubers directly by burrowing into the flesh, causing gouges or holes. Damage is very similar to that caused by the whitefringed weevil.
- Several species of cockchafers can also cause damage to tubers by tunnelling into the tubers. However, not all cockchafers will cause damage even when present in high numbers.
- The black-headed pasture cockchafer in Victoria and South Australia lives below the soil surface but tunnels to the surface to feed on grasses at night. They can be very abundant but do not cause tuber damage.

Potato aphid.

Green peach aphid.

## APHIDS

- Many different species of winged adult aphids can be found in potato crops. Most do not colonise the potato plants, will not introduce viral diseases, and do not require controlling.
- Four species are usually considered potato pests throughout the world but, in Australia, only two are very common: green peach aphid (*Myzus persicae*) and potato aphid (*Macrosiphum euphorbiae*). The other two species are buckthorn aphid and foxglove aphid.
- Aphids are sucking insects that insert their needle-like mouthparts into the plant and feed on sap. When they feed they can transmit a virus if it is present on or in their mouthparts, and likewise pick up a virus from an infected plant.
- Only green peach aphid keeps and carries potato leaf roll virus for its entire life. Green peach aphid can also transmit other viruses and like other aphids,

can transmit viruses but lose the virus after a short time.

- Green peach aphids can be distinguished by their body shape and also the shape of the base of the antennae, which in this species point inward. Wingless forms are usually light green but at times a proportion of the population may turn pink-orange.
- Potato aphids are larger, more slender species without inward-pointing bases on the antennae. Aphids can be distinguished from immature leaf-hoppers by the presence of two projections (cornicles) near their tail.
- There are both wingless and winged forms of aphids. Winged aphids are common when aphid populations need to move (for example, from senescing crops or from overwintering hosts). Wingless aphids are more common on growing crops.

### Damage

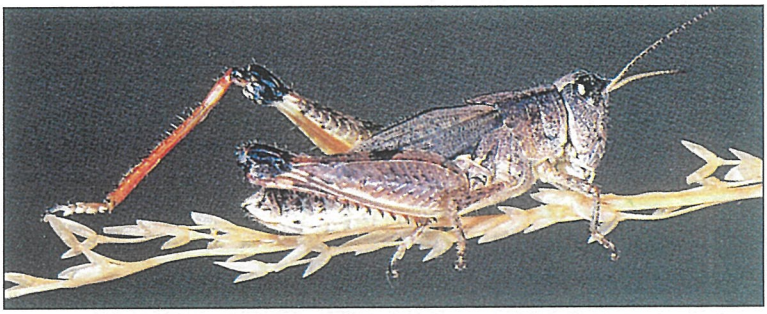
- Virus transmission is the main reason that aphids are of concern in potatoes, but if large colonies of aphids develop on young plants they can weaken the plant due to loss of nutrients.

## GRASSHOPPERS AND CRICKETS

- There are several species of grasshoppers and crickets that can cause damage to potato crops. The most common of these are wingless grasshoppers (*Phaulacridium vittatum*) and field crickets (*Teleogryllus* species).

### Damage

- Damage to crops is often seen in summer after nymphs migrate from grassland or pasture nearby.



Wingless grasshopper.

Burrowing mole cricket.

- They chew holes in leaves, and can strip plants of leaves if present in large numbers. Damage is usually more severe on outer rows adjacent to pasture.

## GREEN MIRID BUGS AND GREEN VEGETABLE BUGS

- The green mirid (*Creontiades dilutus*) is a slender, parallel-sided true bug, growing to a length of 7 to 8 mm.
- Adult green mirid bugs are usually light green or yellow-white and hold their wings folded flat over their back. Immature stages (nymphs) are green and look like smaller versions of the adult but without the

Green mirid bug.

Green vegetable bug.

wings. Very young nymphs can be mistaken for leafhoppers or aphids. Both adults and nymphs have very long antennae.

- Green vegetable bugs (*Nezara viridula*) are very stout, angular insects that look like green versions of shield bugs.
- Adult green vegetable bugs are green, although they vary from dark to light green during the year, and grow to a length of up to 17 mm.
- Nymphs do not have wings and their backs are brightly coloured with red, orange, yellow, green and black markings.

### Damage

- Green mirid bugs produce a chemical that they transmit to plants when they feed. This chemical kills the plant cells in the area where the mirid has put its mouthparts, and so can destroy leaf-growing points or individual leaves.
- Young mirids prefer to feed in the growing terminals and young leaves.

Heliothis moth.

Heliothis caterpillar.

## HELIOTHIS SPECIES AND CLUSTER CATERPILLAR

- Two species of *Helicoverpa* (formerly called *Heliothis*) can be pests of potatoes, especially in hotter, northern growing regions of Australia where they can be more abundant. Species are *Helicoverpa armigera* and *Helicoverpa punctigera*.
- Adult moths are up to 30 mm long, light brown with green eyes.
- Cluster caterpillars can grow up to 35 mm long, have stripes and short black hairs along the length of the body. Their colour is extremely variable, from pale green to dark brown.

### Damage

- Helicoverpa and cluster caterpillars chew holes in leaves, the holes becoming larger as the caterpillars grow. If sufficient caterpillars are present then they can cause serious loss of leaf area. The tougher parts of the leaf (mid-vein) may be all that is left.
- Damage is very similar to that caused by looper caterpillars (*Chrysodeixis* species).

Vegetable leafhopper.

## LEAFHOPPERS

- Leafhoppers are small, wedge-shaped insects that can be extremely abundant in potato crops.
- Sometimes known as jassids, two of the most commonly encountered species are the brown leafhopper (*Orosius argentatus*) and the vegetable leafhopper (*Austroasca viridigrisea*).
- Both species are about 3 mm long as adults, and the brown leafhopper is brown-flecked with white spots, while the vegetable leafhopper is vivid green. Nymphs look like the adults but without wings.

### Damage

- Brown leafhoppers can spread a disease called purple top wilt, but other leafhoppers are not vectors.
- Direct feeding damage by leafhoppers is visible as a mottling on leaves.

## LOOPER CATERPILLARS

- There are two species of looper caterpillars (*Chrysodeixis argentifera* and *Chrysodeixis eriosoma*) that can cause damage to potato crops in Australia.
- They are called loopers because of the way the caterpillars move, looping like a leech. In addition to the legs at the head end of their body, they have two pairs of prolegs near the tail end. To move they arch the body in a loop and then stretch out again.
- The caterpillars are bright green with white stripes down the length of the body. They appear smooth-skinned (as opposed to heliothis which have many hairs or spines along the body).
- They begin life as spherical, white eggs, about 2 mm wide, and then develop into the caterpillars. Fully grown caterpillars can be 30 to 40 mm long.
- Adult loopers are brown but have a distinctive silver patch on the forewing.

*Chrysodeixis argentifera* moth.

A looper caterpillar 'looping'. Note damaged leaves.

### Damage

- Loopers eat the foliage of potato and many other plants. Smaller caterpillars chew small round holes in leaves, while larger caterpillars can eat entire leaves, often leaving just the veins.

## POTATO MOTH

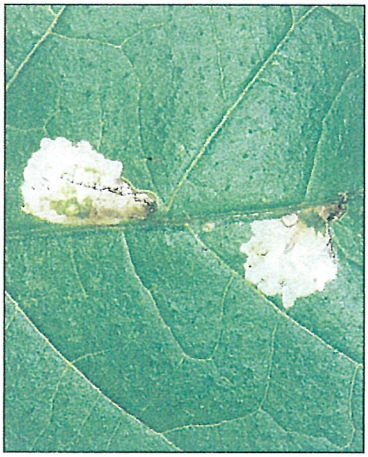
- Potato moth (*Phthorimaea operculella*) is a major pest of potatoes throughout much of the world.
- The adult moth is about 8 mm long and flecked grey-brown.
- Caterpillars can be up to 12 mm long and are variable in colour. They can be cream, green or pink with a black head.

### Damage

- Damage is caused by the immature (caterpillar) stage, not by the adult moth.

Adult potato moth.

Typical potato moth larva leaf mines.

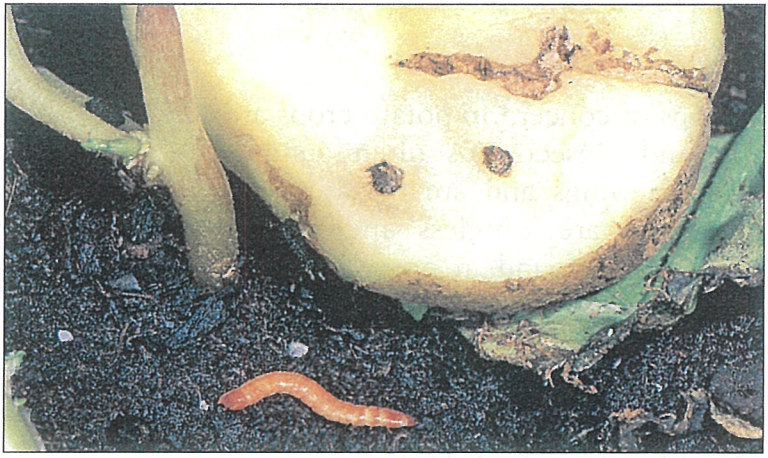


- Caterpillars emerge from their eggs and tunnel into leaves if they are present, or into tubers if the growing stage of the crop is over.
- Caterpillars live between the upper and lower surfaces of potato leaves, eating the tissue inside leaves. They often move along veins in the leaf, which leads to the mid-vein.
- Damage to tubers is often the major concern. Caterpillars tunnel into tubers, beginning by moving just under the surface and then moving deeper. Droppings from the caterpillar accumulate at the entrance to the tunnel.
- Damage can occur in the field or in storage.

## POTATO WIREWORMS

- The potato wireworm that occurs in Australia is a native Australian species (*Hapatesus hirtus*).
- It is a type of click beetle, and the immature (larval)

Potato wireworm and damaged potato.



stages are known as wireworms. The larvae are tough and cylindrically shaped with legs near the head end and a flat plate with two short prongs at the tail end. They are usually yellow-orange but may be pale yellow when they have just moulted. Wireworms grow to be up to 40 mm long.

- The adults are slender, red-brown click beetles.
- It is important to note that there are hundreds of other species of click beetles that can be found near potato crops. These species do not damage potatoes and are not pests. Also, there are insects called wireworms in other crops in Australia and in many crops overseas. These insects are different species to *Hapatesus hirtus*.

### Damage

- It is the immature stages of the beetle, the wireworms, that damage potatoes. They burrow into tubers, usually making a neat round entrance hole on the surface of the tuber and then widening tunnels and cavities within the tuber. Apart from the direct damage, the tunnels are the entry points for fungal rots.

## THRIPS

- Most thrips of concern in potato crops are tiny (up to 2 mm), slender insects most often found in flowers.
- Adults have wings and are highly mobile, while immature stages are wingless and usually yellow. Species commonly found in potato crops are onion thrips (*Thrips tabaci*), plague thrips (*Thrips imaginis*), and, in some locations, tomato thrips (*Frankliniella schultzei*). Western flower thrips (*Frankliniella occidentalis*) are not yet a major problem in potatoes but have the potential to be the most serious thrips pest.

Thrips on sticky trap with scale (1 mm).

Plague thrips.

### Damage

- In potato crops, thrips carrying tomato spotted wilt virus are capable of indirectly causing significant damage.
- Tomato spotted wilt virus is carried by onion thrips, tomato thrips and western flower thrips but is not carried by plague thrips. Plague thrips are possibly the most common thrips found in potato crops, and so it is important to identify thrips before using foliar insecticides.
- Western flower thrips are insecticide resistant, and every application of insecticide leads to an even more resistant strain. Different control approaches are needed depending on the species of pest present.

## 28-SPOTTED LADYBIRDS

- This is a ladybird beetle (*Henosepilachna vigintisextipunctata*) with twenty-eight spots. The adult beetle is yellow-orange with the twenty-eight black spots. (A

28-spotted ladybird and leaf damage.

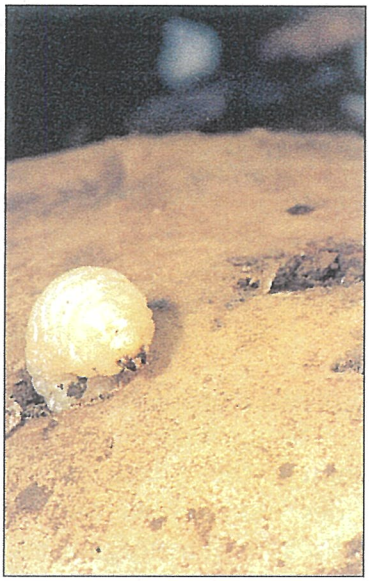
closely related species has twenty-six spots.) This is a leaf-eating ladybird, and is probably the closest we have in Australia to the Colorado potato beetle.

- Immature stages appear to be like other ladybird larvae but they are covered in hairy spines. They are black and yellow and pass through three larval nymphs before pupating. Eggs are laid in masses as are those of the beneficial species.

### Damage

- Damage to leaves is characteristic. Both adult and larval stages eat strips from the leaf, leaving only the veins. They eat several strips side by side, creating a distinctive pattern of damage on each leaf, then they move to a different part of the leaf and begin again.

Adult whitefringed weevil.



Weevil larva (note mandibles) and damaged potato.

## WHITEFRINGED WEEVILS

- The whitefringed weevil (*Naupactus leucoloma*) was accidentally introduced into Australia many years ago, and is now present in all States.
- The damaging stage is the immature grub, which looks like a cream-coloured maggot, with no legs and no obvious head. A pair of dark jaws is the only external feature.
- The adult beetles grow to about 13 mm long, and are grey with white stripes down their sides.

### Damage

- The grubs damage tubers below the ground. They burrow into tubers, leaving round holes or a channel-shaped scar, similar to that caused by slugs.

# Diseases

Potato plants can suffer from a number of disorders or diseases. Some disorders are caused by the physical environment (heat, lack of water and nutrients, cold, herbicides etc.) whilst microscopic organisms cause many diseases. The organisms that cause diseases in plantsare called *pathogens* and include viruses, bacteria, fungi and nematodes.

Pathogens can affect plants in a number of different ways. Destruction of the foliage by leaf pathogens (e.g. target spot) eventually starves the plant of energy and food from the leaves. Several pathogens cause direct damage to the roots, stems and stolons (pruning or rotting) whilst others penetrate the roots and grow or multiply systemically in the plant where they block up the water vessels or release toxins that kill the plant.

Infection of roots and stems by different pathogens can lead to a number of symptoms in the foliage that at first glance look much the same. Often the pathogen that causes the problem cannot be determined without some experience or the help of diagnostic tests. Symptoms in crops can include delayed and patchy emergence of sprouts from the ground, patchy stands, stunting and yellowing of plants, inward rolling or

Tuber symptoms of bacterial soft rot.

'cupping' of leaves, wilting, aerial tubers in the leaf axils and premature death. These sorts of deseases affect the number, size, shape and quality of tubers. Several pathogens damage tubers, generally causing different types of blemishes, lesions or scabs on the tuber skin or rotting of the tuber flesh.

## BACTERIAL SOFT ROT

- Bacterial soft rot (*Erwinia carotovora* subspecies *carotovora*) of tubers can occur throughout all production districts.
- Soft rot is a leaking rot associated with excessively wet soil growing conditions and condensation in sheds and cool stores.
- The bacteria are often secondary invaders in tubers affected by other diseases such as dry rot and pink rot.
- First symptoms are yellowish brown, circular water-soaked lesions around lenticels, which are

often enlarged in excessively wet soil. Under dry conditions, these lesions stop spreading and become brown, slightly sunken dry depressions in the skin. Under moist conditions, however, the spots can enlarge rapidly and tissue underneath will decompose. Affected tuber tissues are very wet, creamy to light beige in colour and become greasy. Soft rot can develop on tubers in sheds and cool stores and on the exposed surface of cut setts planted in cold, wet conditions. Clear watery soft rots under the lenticels of tubers that have been washed for the fresh market are not uncommon on supermarket shelves.

## BACTERIAL WILT, BROWN ROT

- Bacterial wilt, also known as brown rot, is caused by the bacteria *Ralstonia solanacearum* and is a very serious disease of potatoes around the world.
- This disease occurs sporadically and locally in parts

Dead eyes and vascular ring pattern of bacterial wilt.

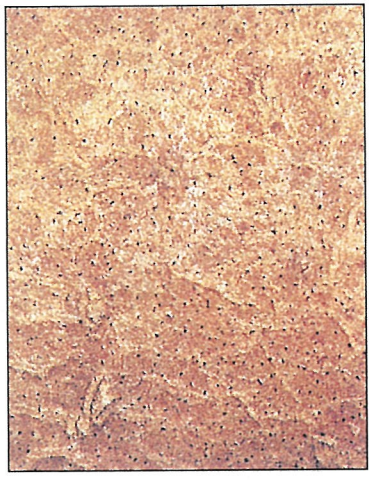
of Australia. However, in the past, entire production areas (often those with swampy ground) were abandoned because of consistently severe outbreaks of the disease.

- The disease affects both the plants and potato tubers. It is first seen in the crop as a wilt, starting at the top of a single stem and later affecting the entire plant (bacterial wilt symptom).
- A milky slime oozing from the end of a cut stem placed in a glass of water is a characteristic sign of this disease. Glistening droplets of slime are seen in the vascular ring when an affected tuber is cut in half and lightly squeezed.
- A bacterial slime exudes from the eyes of affected tubers resulting in characteristic 'dirty eye', 'sore eye' or 'jammy eye' symptoms on freshly harvested tubers.

## BLACK DOT

- Black dot, caused by the fungus *Colletotrichum coccodes*, is a common disease of the tuber skin, although less common than silver scurf. Black dot describes the numerous tiny black, dot-like structures (micro-sclerotia) on affected tubers, stolons and roots and on stems above and below ground.
- The symptoms on tubers closely resemble those of silver scurf, and the two will often be confused. Black dot patches on tubers are somewhat greyer than those of silver scurf and lack the silvery sheen.
- Greyish brown spots and patches (lesions), sometimes tinged with green (from 1 to 2 mm across and larger or covering large areas of the skin), can be seen on tubers at harvest. These patches are most common on the stolon end of the tuber.

Black dot symptoms on a whole white potato.



Black dots (enlarged).

- Severe infection of roots, stems and stolons can lead to yellowing of foliage, wilting and premature death of plants. These symptoms can be confused with wilts caused by *Fusarium*, *Rhizoctonia* or *Verticillium*.
- When pulled from the soil, the roots and stems have a 'stringy' appearance because their outer layers are sloughed off. Abundant black dots can be found both externally and internally in the diseased roots and stems.
- The fungus also causes a dry, stem-end rot that extends several millimetres deep into the tuber tissue.

## BLACK LEG

- Black leg is caused by a number of *Erwinia* bacteria and affects potatoes in the cooler cropping areas.
- Black leg describes the characteristic inky black, slimy rot of the lower stems of potatoes. The rot extends from a rotting mother tuber into the stems.

Crop symptoms of black leg.

- Affected stems have a 'fishy' odour. The top leaves of affected plants turn pale green and become 'cupped'. Affected stems turn yellow and wither or wilt. These stems are stiffer than normal with erect leaves and may be hidden in the crop because their growth is retarded.
- Typically, the rot extends from the stolon end into the internal middle of the tuber. Tubers may also be infected via lenticels and wounds inflicted during harvest.
- Individual diseased plants may be scattered throughout the crop. Under wet conditions tubers can rot extensively resulting in yield loss.
- Contaminated tubers are at risk of rotting in store, or present a risk for the next crop when used as seed.

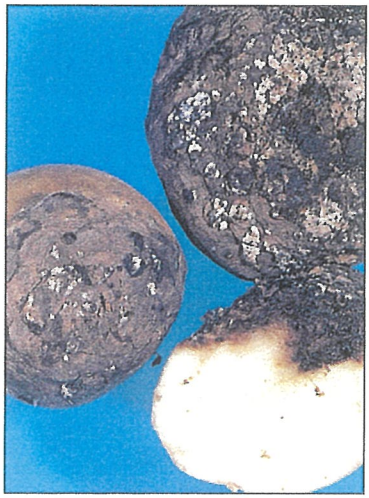
## COMMON SCAB

- Common scab is caused by species of *Streptomyces* (usually *S. scabies*) which belong to a group of

Varying appearance of common scab.

organisms with characteristics of both bacteria and fungi.

- In Australia, common scab has only been a consistent problem in localised areas such as the north coast of Tasmania. More recently, the disease has also become common where potatoes are grown in sandy loams previously used only as permanent pasture for raising stock.
- Common scab is favoured by warm, dry spring and summers.
- Symptoms of common scab vary considerably depending on potato variety and the population of pathogen. Symptoms on tubers can be confused with those of powdery scab, root-knot nematode, root lesion nematode and the scab-like symptoms caused by *Rhizoctonia solani*.
- Symptoms of common scab include superficial circular, rusty coloured net-like lesions (5 mm), brown,



Dry rot on tubers caused by *Fusarium*.

Fusarium wilt in a crop.

roughly star-shaped, crater-like lesions (5 to 15 mm), the larger ones of which are often raised (1 to 2 mm), and deep pitted lesions. One or more of these symptoms may be found on a tuber at one time.

- The first signs of the disease are minute reddish or brown spots on young developing tubers. These spots enlarge as tubers expand.

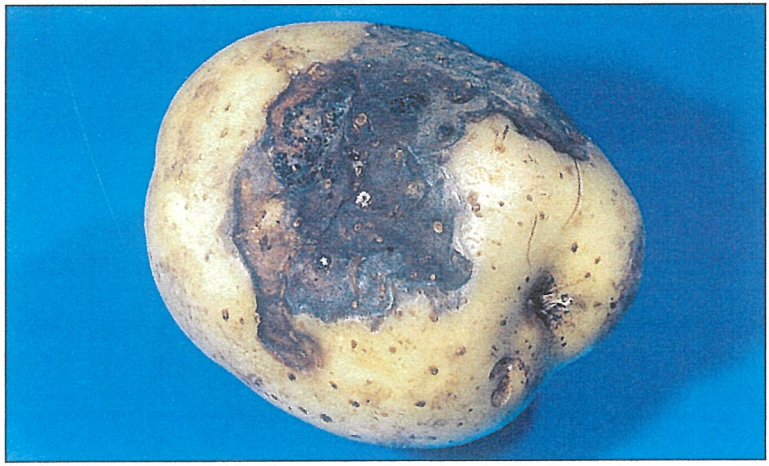
## FUSARIUM DRY ROT AND SEED PIECE DECAY

- Fusarium dry rots of tubers, caused by various species of the *Fusarium* fungus, can occur in all cropping areas. The disease can affect tubers in storage and cut surfaces of seed setts both before and after planting.
- Damage to the tuber skin during harvest, storage, grading, and transport is a prerequisite for dry rot. The fungus cannot infect the intact tuber skin or lenticel (pore).

- First signs of the disease on tubers are small brown patches on the tuber skin that develop within weeks or even several months after harvest. The patches slowly develop into a characteristic dry rot.
- In dry conditions the patches increase in size and the skin shrinks resulting in characteristic concentric wrinkles. The underlying infected flesh of the tuber becomes brownish and cavities lined with cottony growth of the fungus may develop as the affected tissue dries out.
- In moist conditions the affected tissue may be invaded by soft rotting bacteria which rapidly rot the remainder of the tuber.

## FUSARIUM WILT

- Fusarium wilt refers to the rapid wilting of plants, mid to late in the season, caused by one or a number of species of the fungus *Fusarium*.
- Affected plants turn yellow, wilt, often during hot dry weather, and die prematurely. Yellowing begins at the lower leaves and progresses up the plant. Wilting can be very rapid. Other symptoms include an inward rolling ('cupping') of the leaflets, rosetting of the plant tops ('cupped leaves and bunched tops), purpling of the aerial parts and aerial tubers in the leaf axils.
- Characteristic of many fusarium wilts is a brown stain in the ring of water-conducting vessels which can be seen when the stem is sliced across near its base. Below ground, the outer layers of the roots and stems show decay. Symptoms on tubers include a dry stem-end rot and internal browning of the water vessels.



Tuber showing symptoms of gangrene (Phoma rot).

## GANGRENE, PHOMA ROT

- Gangrene, also known as Phoma or 'Thumb-mark' rot, caused by the *Phoma exigua* fungus, is primarily a disease of stored potatoes.
- The disease generally occurs in the cooler production districts and usually occurs after mechanical damage to the skin during harvest and handling (grading, transport, etc.). The disease can be a serious problem for seed growers who need to store seed at low temperatures (below 5°C).
- Symptoms of gangrene take the form of black 'thumb-mark'-like depressions on the tuber surface. These are not usually seen until at least a month after harvest.
- Clusters of spores of the fungus appear as black 'pin-heads' on the surface of older lesions.
- In cross-section through the tuber, damage is first seen as a shallow brown dry rot with a blackened margin. This rot can spread deep into the tuber.

Petiole symptoms of late blight.

Close-up of lesion caused by late blight.

## LATE BLIGHT, IRISH BLIGHT

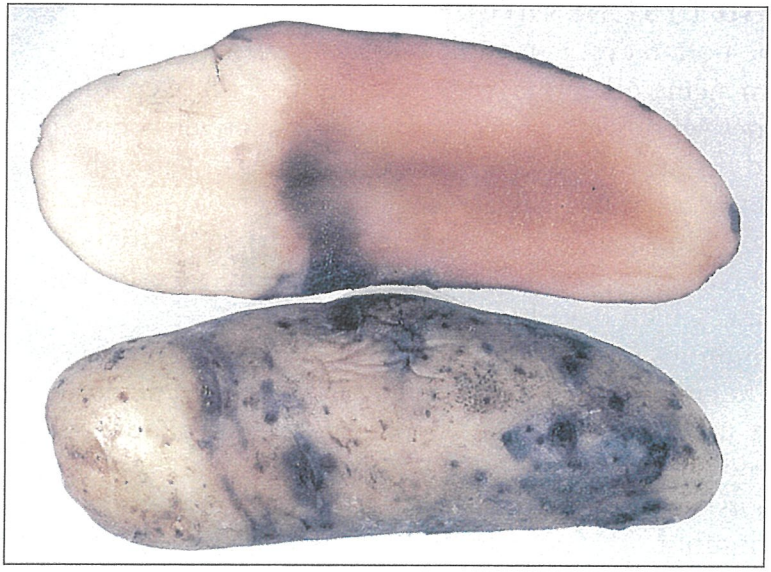
- Late blight is probably the single most important disease of potatoes around the world. The Irish 'potato famine' of the 1840s was caused by *Phytophthora infestans*, the fungus that causes late blight.
- In Australia, however, the disease occurs only sporadically in some districts, most often in the central highlands region of Victoria and the north coast of Tasmania.
- The disease develops after several days, usually during periods of unusually warm, calm, sultry weather that is relatively warm (15 to 20°C) in mid to late summer, when morning dews are common.
- The disease is first obvious as large (5 mm or more) water-soaked, grey to brown blotches on potato leaflets. Under very humid conditions, a light cottony growth can be seen on the underside of leaflets along the edges of the lesions.

- The lesions develop and spread very quickly, eventually turning black, extending to the petiole and down the stem. Severely affected, blackened water-soaked leaflets will 'hang' from the petiole. The affected tissue gives off a distinctive odour.

## PINK ROT

- Pink rot caused by species of the water mould fungus (*Phytophthora erythroseptica*, *Phytophthora* spp.) occurs to some degree in most major cropping areas in Australia.
- The disease is particularly serious in some traditional production districts with heavy, well-irrigated soils, or in relatively new cropping areas where sandy loam over a clay layer can become water-logged with rain or heavy irrigation.
- Tubers affected by pink rot have a rubbery or

Typical tuber symptoms of pink rot.

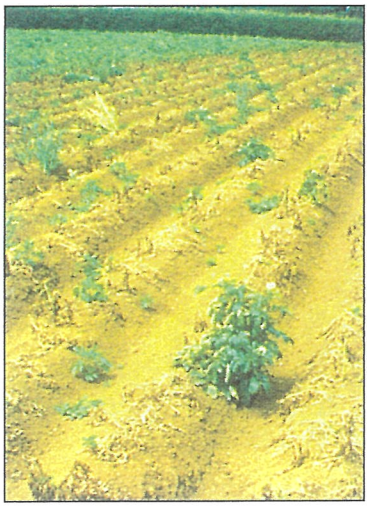


spongy texture and leak when squeezed hard. The skin over the affected area is usually discoloured and rather loose with blackened lenticels (pores).

- Within several minutes of cutting a rotted tuber, the diseased tissues turns pink, darkening to a deep salmon pink, and becoming purplish-brown to almost black after several hours. Healthy and diseased tissues are often separated by a dark line which is visible through the skin.
- Other symptoms of pink rot include wilting of plants, usually late in the season. The fungus infects the roots, spreading to the stems, stolons and into the tubers.
- First symptoms in a crop include paling and yellowing of leaves accompanied by an inwards rolling and curling of the young leaflets.
- Aerial tubers may also form. Affected plants usually occur in patches.

## POTATO CYST NEMATODE

- The potato cyst nematode (*Globodera rostochiensis*, the golden nematode) is a very destructive pathogen of potatoes worldwide and can only be effectively controlled through the use of resistant varieties or through very long rotations.
- Infestations of the nematode in Australia are restricted to several properties in Victoria and Western Australia which have been quarantined.
- Symptoms of damage from nematode infestation are small to large sharply defined patches of stunted plants which are darker and flower later than surrounding healthy plants.
- Roots systems are bushy because infested roots branch more.



Crop infested with potato cyst nematode.

Cysts of the potato cyst nematode.

- Characteristic female 'cysts' (egg sac) are seen as white 'pinheads' along the root around six to eight weeks after planting. These later colour to a golden yellow and later brown.

## POTATO LEAF ROLL VIRUS

- Potato leaf roll is caused by strains of the potato leaf roll virus.
- In traditional production areas in Australia, the disease has largely been controlled by planting certified seed potatoes.
- The reinfection of crops is generally very low because of low aphid numbers. However, the production of potatoes in many new areas not previously cropped to potatoes has seen a re-emergence of potato leaf roll.
- Symptoms of leaf roll depend on the interaction

Curled leaves and typical secondary symptoms of potato leaf roll virus.

between the virus strain, the potato variety and the weather.

- On plants infected in the field ('primary leaf roll'), the disease first appears in the younger leaves at the top of the plant which roll inwards and turn pale yellow and may develop red margins or a purplish tinge.
- Symptoms may not develop on plants infected late in the season, although the virus may have already spread to the tubers.
- On plants that grow from infected tubers ('secondary leaf roll'), the entire plant is affected, although the older leaves near the base roll inwards more than do those near the top.
- Young leaves are slightly pale, appear stiff, dry and brittle, and sound paper-like or leathery when touched and are sometimes brown. Affected plants are often stunted and rigid.

Galls on roots caused by powdery scab.

## POWDERY SCAB

- Powdery scab, caused by the fungus *Spongospora subterranea*, is a serious disease of potatoes in Australia, particularly for growers of washed, fresh market crops and for seed producers.
- The disease is associated with cool, wet conditions during early tuber initiation and development.
- The first signs of powdery scab may be on the roots, where the disease appears as small light-coloured galls or warts roughly between 1 and 10 mm in diameter.
- On tubers, the disease is first seen as light coloured pimples or warts (between 2 and 10 mm diameter) that erupt through the skin. The warts eventually turn brown and powdery, particularly when exposed to the air soon after harvest.
- Both root galls and tuber pustules contain the characteristic 'sporeballs' of the fungus.

Tubers showing differing symptoms of powdery scab.

Single tuber showing effects of powdery scab.

- The powdery material is usually superficial and can be scraped off the potato's skin with a fingernail.

## RHIZOCTONIA CANKER AND BLACK SCURF

- Disease caused by the fungus *Rhizoctonia solani* AG3 is common and widespread throughout most potato cropping areas of Australia and around the world.
- The fungus produces a range of symptoms on the potato plant, the best known being black scurf, the reddish-brown to black sclerotia (crusty-like lumps) on the tuber surface.
- The fungus attacks the underground parts of plants. New sprouts on seed potatoes can be damaged soon after planting, causing elongated reddish-brown to grey depressions, lesions or 'cankers' along the sprout.
- Damage to the stem results in infection of the stem causing stunting, an inward-rolling curling ('cupping') and pinching of leaves along the main vein, giving the tops of affected plants a 'rosette' appearance, a yellowing, reddening or purpling of stems and leaves, and in

Leaf curling and colouring symptoms caused by Rhizoctonia.

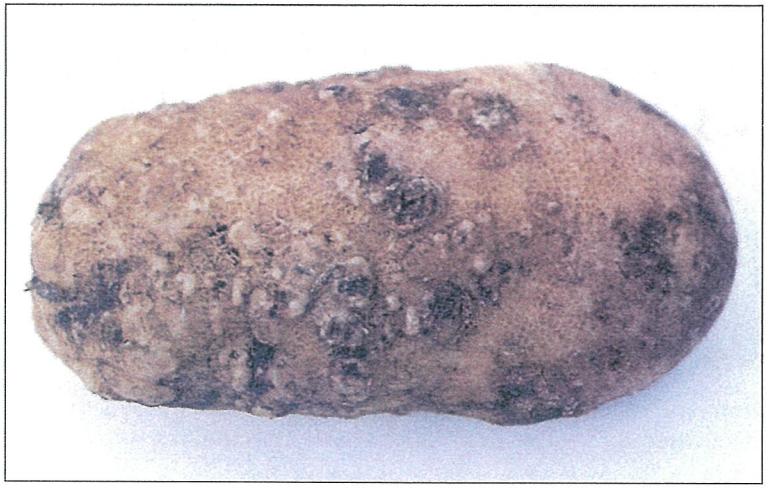
Stem canker and aerial tubers caused by Rhizoctonia.

Black scurf.

Stem canker.

extreme cases, wilting and death, particularly after periods of hot weather.

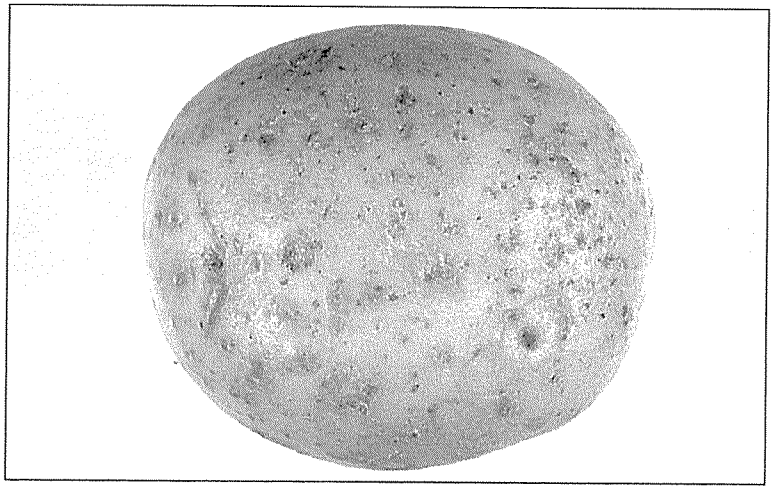
- Plants without fatal stem lesions can have numerous green to reddish-purple aerial tubers in the leaf axils and have tuberous or bottle-shaped leaf stems.



Tuber symptoms of the root knot nematode. Note wart-like knobs.

## ROOT KNOT NEMATODE

- Almost all of the major crops of the world are hosts to species of the root knot nematode. A number of species of the nematode (*Meloidogyne* species) can do very serious damage to potatoes.
- In Australia, however, root knot nematodes usually only cause significant problems sporadically in localised areas (*M. incognita*, *M. javanica*, *M. arenaria*, *M. hapla*), even though evidence of root knot damage can be found in all potato cropping areas.
- Root knot damage is generally more common in the warmer cropping areas with sandy soils or during particularly warm, dry summers in the cooler cropping areas where potatoes are grown without irrigation.
- Above-ground symptoms are easily overlooked. Plants may show varying degrees of stunting, yellowing of leaves and a tendency to wilt under moisture stress.
- Symptoms on roots include swellings (referred to as



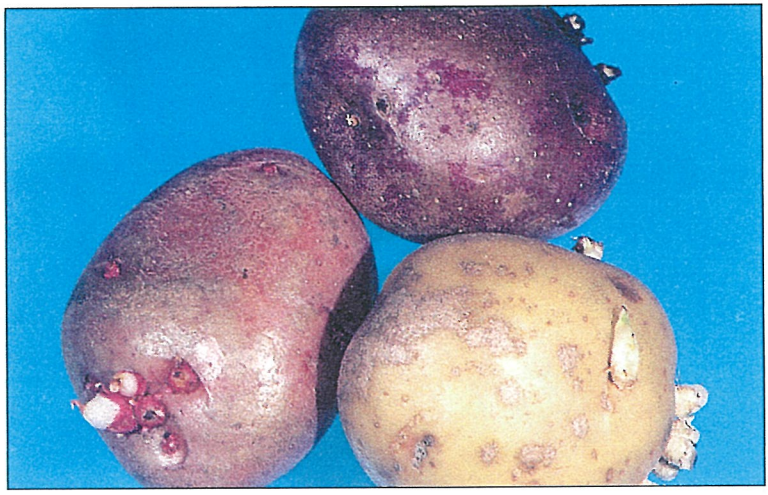
Lesions on tuber caused by the root lesion nematode.

galls, beads or knots) of varying size and shape, hence the name 'root knot'.

- Nematodes (also known as eelworms) are small (less than 1 mm in length) worm-like organisms inhabiting soil.

## ROOT LESION NEMATODE

- A number of different species (*Pratylenchus crenatus, P. penetrans, P. thornii, P. neglectus*) of the root lesion nematodes can be found in potato cropping soils around Australia.
- The nematode is associated with yield loss and damage to tubers in some heavily cropped production areas with sandy soil.
- Symptoms of damage to roots by high densities of root lesion nematodes include patches of stunted plants with poor vigour which may die prematurely. Plants may show nutrient-deficiency symptoms and drought intolerance.



Silver scurf on a variety of potatoes.

- Affected roots show elongated, yellowish-brown to dark brown and black lesions scattered over the root system. Symptoms on tubers include small pimples (less than 1 mm) protruding from the skin, or small purple-brown areas 0.5 mm deep and surrounded by a slightly depressed border.

## SILVER SCURF

- Silver scurf (*Helminthosporium solani*) is one of the most common blemish diseases of potato tubers in Australia and around the world.
- Silver scurf spoils the appearance of a tuber, reducing marketability of consignments of washed, fresh potatoes. Symptoms are grey to silvery blotches on the skin of a tuber.
- The disease is first seen as small pale brown spots on the stolon end (best seen when tubers are washed). The silver blotches can look 'sooty black' on tubers kept in

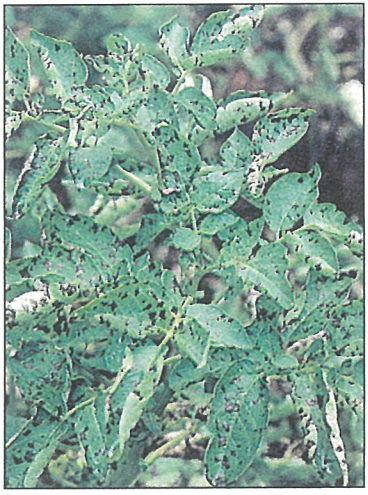
a warm (greater than 10°C) humid environment as a result of the fungus producing an abundance of black spores in the lesions.

- The layers of diseased skin lift slightly and the air trapped underneath gives the lesions their silvery sheen. The diseased areas of skin are more permeable and severely affected tubers become shrivelled and wrinkled after prolonged storage.

## TARGET SPOT, EARLY BLIGHT

- Target spot, also known as Early blight, caused by the fungus *Alternaria solani*, is a very common disease of potato foliage, occurring every season in most crops all over Australia.
- The fungus infects the leaves causing dark brown lesions that consist of concentric rings, hence the name target spot.

Plant infected with target spot.



Close-up of leaves infected with target spot.

Close-up of typical ring pattern of target spot infection.

- Lesions first appear as small (1 to 2 mm) dry, papery spots, which grow in size and become more angular as they meet the veins on the leaves. The foliage of a crop becomes peppered with lesions.
- Entire leaves die, turn brown, but do not fall off. Dead foliage becomes crisp and the plant looks as though it has been scorched.
- The fungus can also infect tubers, although the symptoms are rarely seen in Australia. Tuber lesions are dark, sunken, circular to irregular in shape, and often surrounded by a raised purple to dark brown border.

## TOMATO SPOTTED WILT VIRUS

- Tomato spotted wilt virus (TSWV) can cause significant damage in localised areas from time to time.
- It is responsible for substantial losses in fruit, vegetables and ornamental crops around the world and has one of the largest host ranges of any plant virus.

- The virus is transmitted by tomato and onion thrips in Australia, but western flower thrips are also vectors.
- Symptoms caused by TSWV include brown spots or rings on the leaves and stems, death of the top of one

Plant infected with tomato spotted wilt virus (centre).

Close-up of leaf symptoms of tomato spotted wilt.

or more stems and sometimes the death of the whole plant. Symptoms can be confused with those of target spot and can vary between cultivars.

- Plants become noticeably stunted and badly infected plants can die prematurely.
- Tubers produced by infected plants may appear normal or may be distorted or cracked and can have sunken black spots on the skin. Internally, affected tubers can have varying degrees of rusty or dark shadowing, flecking, spotting or severe necrosis (dark areas where cells have died).

## VERTICILLIUM WILT (EARLY DYING)

- Verticillium wilt (*Verticillium dahliae* and *V. albo-atrum*) causes early or premature senescence ('early dying', 'early maturity') of plants. Symptoms of the disease are difficult to distinguish from normal senescence, as crops appear to die naturally.

Plant infected with verticillium wilt.

- At first, the disease may just retard the growth of infected plants. Later individual plants may wilt, especially on hot, sunny days.
- Typical symptoms of individual plants is that half a leaf, one leaf, or one or more leaves on one side of a petiole, can show one or more symptoms of wilting, uneven chlorosis (blotchiness), yellowing and necrosis (browning). Yellowing and death proceed up the stem, which often remains erect.
- A distinguishing feature of verticillium wilt is a golden to brownish-yellow discolouration of the vascular system (circle of water-conducting vessels inside the stem) which progresses up the stem as infection spreads.

## WHITE MOULD *(SCLEROTINIA)*

- White mould can affect many different crops, including broadacre and vegetable crops such as Brassicas (for example, cabbage, broccoli, oilseed rape), lettuce, tomato, beans and legumes (soy bean, faba bean, lupin) and sunflowers. From time to time it causes economic damage in potato crops.
- In Australia, the disease appears to be caused mostly by the fungus *Sclerotinia minor* but can also be caused by another species *Sclerotinia sclerotiorum*. The disease may become more common as potato production expands into broadacre cropping areas and into areas using centre-pivot irrigation.
- Typical symptoms are water-soaked lesions covered with a cottony white growth or mycelium (a mat of fungal threads), mostly on the main stem at the soil line and on stem branches that make contact with the soil.
- The disease can also appear in the angles of the lateral stem branches, leaves, petioles and flower bases.

This mycelium is also present in the cavities that develop inside the affected stems.

- Diseased stems often turn yellow and may be confused with stems affected by the bacterial disease black leg; the difference is that the white mould lesions do not turn black.

# Further Reading

*Potato Diseases. Diseases, Pests and Defects* (1996).
Editor in chief, E. P. Asscheman, NIVAA Holland.

*Compendium of Potato Diseases.*
American Phytopathological Society, 2001 edition,
New York.

*Insects and Diseases of Australian Potato Crops,*
Melbourne University Press, Carlton, 2002

This handy field guide describes and illustrates the insects and diseases most likely to be encountered by Australian potato growers. It is intended for use in the paddock.

- **simple, durable, easy to use**
- **fully illustrated to aid identification**
- **essential for anyone serious about growing potatoes**

A larger and more detailed companion book, *Insects and Diseases of Australian Potato Crops* (MUP 2002), provides extra information on which to base decisions about control options.

**Paul Horne** has given help on insect pest control to potato farmers since 1987 using IPM. He runs a company of entomologists providing specialist research and advice. **Rudolf de Boer** is a senior plant pathologist with Agriculture Victoria, and for over 15 years has run research projects on control of potato diseases. **Denis Crawford** is an independent professional photographer with an international reputation in macro photography. He and Paul Horne are the authors of *Backyard Insects* (MUP 1996).

HORTICULTURE

Cover illustration: A flowering potato crop in Gippsland; inset, red and blue beetles, *Dicranolaius bellulus*, photographs by Denis Crawford
Cover designed by Pigs Might Fly Productions

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