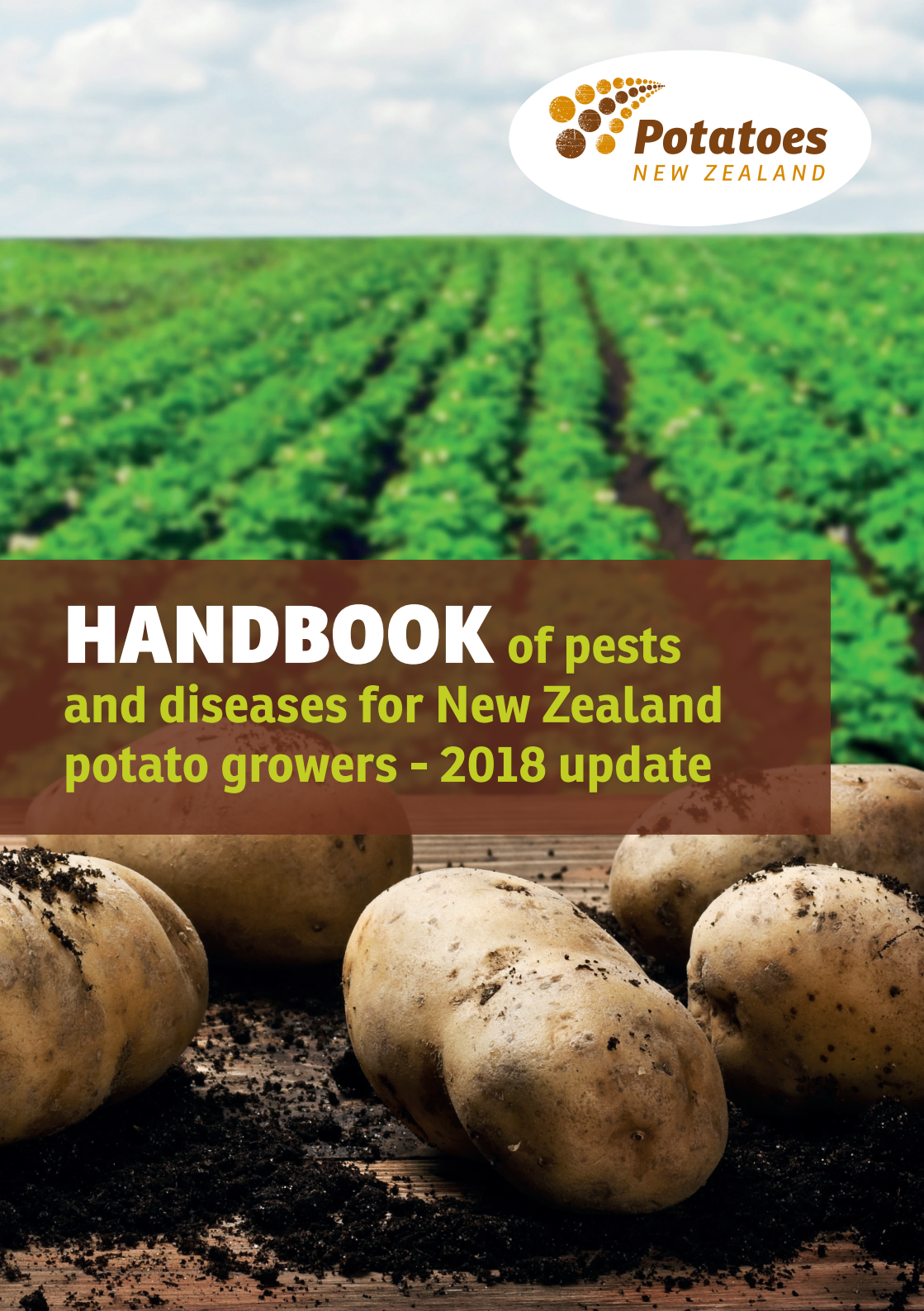
Potatoes
NEW ZEALAND

HANDBOOK of pests and diseases for New Zealand potato growers - 2018 update



Handbook of pests and diseases for New Zealand potato growers.
Revised Third Edition.

Edited by Market Access Solutionz Ltd - Sally Anderson, Stephen Ogden and Sarah Williamson.

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The production of this handbook was funded by levies paid by the members of Potatoes New Zealand Inc. This Revised Third Edition updates the 2017 edition. Pest descriptions have been reviewed, some images replaced, and several new exotic pests and diseases have been added.

The editors are grateful to image owners for granting permission to reproduce their images in this handbook. The source of each image is acknowledged in the photograph's caption.

Introduction

Potatoes New Zealand has entered into an agreement with the Government to share responsibility for biosecurity readiness and response. The publication of the Third Edition of this handbook demonstrates the industry's commitment to improve awareness of biosecurity threats. The "Sector Risk Organisms" section describes several pests and diseases that could have a dramatic impact on the viability of potato growing in New Zealand. I encourage you all to familiarize yourself with these symptoms and to notify MPI immediately if you suspect you have found something new.

The handbook you are holding is designed to help growers deal with these problems and make the most of the opportunities we have. This is a great resource for the industry, and I hope it will be useful for many years to come.

Chris Claridge
CEO, Potatoes New Zealand Inc.

FUNGI

Black dot (*Colletotrichum coccodes*)

Symptoms

Typical symptoms of black dot infection are slow wilting of plants followed by yellowing of the foliage, leaf rolling, and sometimes plant death. Young leaves may also show vein death. Stems can have a bleached appearance and may have a large number of small, black pinprick-like sclerotia on the surface. Stems dry out and the plant may collapse. Below ground there can be poor root growth, which causes a stringy appearance with purple root colouring. Infection may advance to tubers which show grey-brown lesions resembling silver scurf or black scurf. Unlike these diseases, however, black dot lesions are quite dark and are not shiny, and patches of grey skin will be dotted with small black sclerotia. Many of these symptoms are similar to or may be present in combination with other diseases such as Verticillium wilt or dry rot, so a correct identification may be difficult.

Transmission

The black dot often survives over winter on plant debris, and can be introduced on seed potatoes.

Notes

Black dot is usually more damaging at high temperatures in poorly draining soils.

Close up of black dot symptoms on a potato tuber's skin
Image courtesy of AHDB Potatoes © Sutton Bridge CSR

Black dot stem infection.
Image courtesy of Ontario Ministry of Agriculture, Food and Rural Affairs (OMFRA), © Queen's printer for Ontario, 2018. Reproduced with permission.

Black scurf/Rhizoctonia canker

(*Rhizoctonia solani* (teleomorph *Thanatephorus cucumeris*))

Symptoms

Black scurf/Rhizoctonia canker may cause poor plant emergence or result in damaged sprouts emerging from an infected tuber. As plants grow, brown stem cankers and sunken brown or black lesions on roots and sprouts may appear. Plants may develop stunting, yellowing or purpling of leaves and leaf rolling. Aerial tubers may also be seen. Eventually lesions may girdle the stem and cause the death of emerging haulms. In cool, damp weather a white carpet of fungal threads may form around the base of the stem. Black scurf/Rhizoctonia canker causes browning, malformations, cracking, and scabbing on tubers, but the most common symptom is the development of dark brown or black sclerotia on the tuber surface. These sclerotia look like soil but will not wash off. Freshly harvested tubers affected by Black scurf/Rhizoctonia canker often have a strong mouldy smell.

Transmission

This fungus has a wide host range and is able to remain viable in the soil for several years. It is also transmitted to new areas on infected seed potatoes.

Notes

Black scurf/Rhizoctonia canker is prevalent in cool, wet spring weather with infection most commonly occurring early in a potato plant's growth cycle. Continued low temperatures and high humidity encourage further infection.

Leafroll symptoms caused by infection of stems by *Rhizoctonia*.

Rhizoctonia canker lesions on a potato stem.

Typical black scurf symptoms on a potato tuber.

Dry rot and Fusarium wilt (*Fusarium* spp.)

Symptoms

Dry rot can be serious problem on stored tubers. Dry rot most commonly occurs when tubers are damaged during harvest as this allows an infection to occur. A shallow, brown lesion will often develop causing a discoloured ring. The tuber's tissues shrink and collapse and white or pink fungal mould may be seen. Tubers infected by Fusarium will often go on to develop secondary infections from soft rot bacteria. Dry rot will spread under warm storage temperatures and can also be a serious problem in cut seed tubers if they are not stored correctly prior to planting. If infected tubers are sown, they may simply rot in the field or, as plants grow, they may develop Fusarium wilt – this is caused by the same fungus but has quite different symptoms. Fusarium wilt infection begins in the plant's roots and causes wilting of the lower leaves, patchy coloured foliage, and finally plant collapse. This disease resembles Verticillium wilt or early dying.

Transmission

Fungal spores are carried in soil and infect damaged, bruised or uncured tubers. Fusarium may be spread by insects which are attracted to diseased tissue.

Notes

Post-harvest rots develop most rapidly under warm, damp conditions.

Dry rot symptoms on potato tubers.

Plant wilting and collapse caused by infection with *Fusarium* spp.

Early blight (*Alternaria solani*)

Symptoms

Early blight causes irregularly shaped to circular, dark coloured spots on leaves that may have a yellow border. These spots have a characteristic 'target spot' appearance with alternating light and dark rings. Lower leaves are often infected first. As the disease progresses, the spots merge to cover large areas of leaf tissue and the leaves eventually wither and die. If blight is severe, stems and tubers may also become infected. Tuber infection may occur at harvest through bruising or wound damage. The tuber's skin develops dry, dark coloured, circular depressions and is leathery or corky.

Transmission

Alternaria solani survives on plant debris in the field from one season to the next, and spores are spread by wind, rain, and irrigation water both within and between crops.

Notes

Plants which are under stress are more susceptible to blight infection and alternating wet and dry conditions (such as those caused by overhead irrigation) may favour disease development.

Symptoms of early blight on potato leaves (left) compared with late blight symptoms (right).
Image courtesy of Peter Wright, Plant & Food Research.

Symptoms of early blight infection in potato leaves.
Image courtesy of Peter Wright, Plant & Food Research.

Symptoms of early blight in a potato tuber, showing dry, dark, circular depressions.
Image courtesy of Ontario Ministry of Agriculture, Food and Rural Affairs (OMFRA), © Queen's printer for Ontario, 2018. Reproduced with permission.

Gangrene

(Boeremia foveata (syn. Phoma exigua var. exigua and Phoma exigua var. foveata))

Symptoms

Gangrene tuber rots are usually firm with irregular, dark depressions on the tuber surface. Infections begin through wounds, eyes, or lenticels with initial stages forming a “thumb mark” which then develops into larger, irregularly shaped lesions with pronounced edges. Deep internal rots may develop as the infection develops while tubers are in storage. In some instances, black sclerotia may also be visible on the tuber surface.

Transmission

Gangrene is often introduced on infected seed tubers, but the fungus can also survive from season to season in the soil.

Notes

Moist soils combined with low temperatures will produce ideal conditions for gangrene, particularly if harvest is delayed or mature tubers are stored in the ground.

A typical, irregularly shaped gangrene lesion on a potato tuber.

Gangrene of a potato tuber.

Grey mould (*Botrytis cinerea* (syn. *Botryotinia fuckeliana*))

Symptoms

Grey mould is often first seen as a grey, fuzzy growth on potato flowers or on the edges of leaves. Flowers may drop, passing the infection on to the leaves, where tan coloured lesions develop. Grey mould may spread to the stems where it develops into a brown, slimy rot covered in grey fuzzy growth. Grey mould can contribute to poor plant growth and the establishment of other diseases. Tuber infection is rare, and only occurs after tubers are damaged. Infected tubers are generally wrinkled, with soft wet subsurface tissues.

Transmission

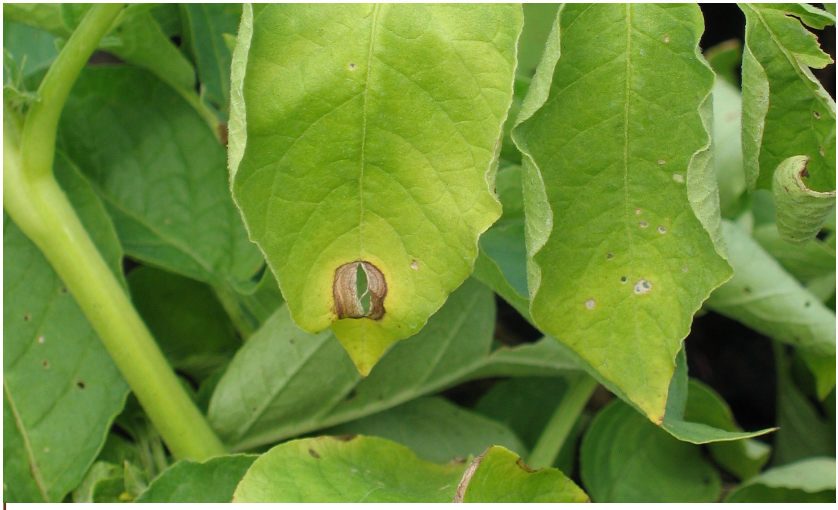
Wind or rain distributes grey mould spores. *Botrytis* can over-winter on plant debris, or other hosts.

Notes

Cool and wet conditions are generally required for infection to occur. Excessive plant growth may result in a canopy which stays wet long after rainfall and irrigation, which promotes infection.

Leaf lesions caused by grey mould.
Image copyright Dr Phillip Wharton, Michigan State University.

Advanced leaf lesion caused by grey mould.
Image copyright Dr Phillip Wharton, Michigan State University.



Leaf lesions caused by grey mould.
Image copyright Dr Phillip Wharton, Michigan State University.

Late blight (*Phytophthora infestans*)

Symptoms

Initial leaf symptoms of late blight include small, darkly coloured, and irregularly shaped spots surrounded by a light green halo. During cool, moist weather these spots rapidly expand into large, dark brown or black lesions. Under moist conditions a white velvety growth may be seen on the infected leaves and stems. Infection often appears first on the lower parts of the potato plant then travels both up the stem and down towards the tubers. Blackened and limp leaves may hang from the stems, growing points may collapse, and the stem base can become infected. Damaged tissue can give off a distinctive acrid smell. Infection can reach tubers where it may initially cause only superficial lesions, but sunken, wet, reddish-brown patches can develop and spread until the tuber is entirely rotted. Late blight rot of tubers is often accompanied by soft rot.

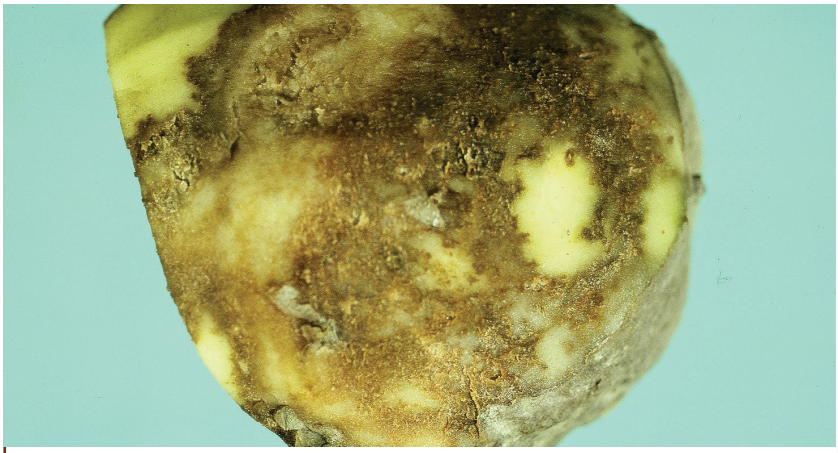
Transmission

Transmission of late blight arises from either infected tubers or volunteer plants. As plants grow, spores are released from the sites of infection to wash or blow across to uninfected tissue.

Notes

Late blight is one of the most destructive potato diseases, and it affects all parts of the potato plant. Late blight reduces both the quantity and quality of tubers and can result in the total loss of a crop.

Brown lesions on potato leaves caused by late blight.
Image courtesy of Peter Wright, Plant & Food Research.



Sunken brown patches on a potato tuber, caused by late blight.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Leak (*Pythium ultimum* var. *ultimum*)

Symptoms

Leak infection causes grey-brown and water-soaked skin discolouration around tuber bruises or wounds. These areas gradually swell and the skin turns dark brown. Infected tuber tissues become spongy and wet, changing from grey to brown and eventually black. A distinct, dark coloured line develops between diseased and healthy tissue. This disease generally rots the tubers from the inside out, and within a week the tuber may be so rotted in storage all that is left is the shell of the tuber. Infections may be accompanied by a foul, sweet smell.

Transmission

Pythium fungi are soil-borne pathogens with a wide host range, occurring in most agricultural soils. The fungus enters tubers only through wounds and care should be taken to avoid damaging tubers at harvest.

Notes

Tubers must be injured for infection to occur, and high temperatures and dry conditions favour leak development. *Pythium* may also be responsible for the decay of seed tubers if conditions are warm and wet after planting.

Advanced symptoms of leak of a potato tuber.
Image courtesy of Lian Heng Cheah, Plant & Food Research.

Symptoms of leak infection of a potato tuber.
Image courtesy of DA Inglis, Pacific Northwest Vegetable Extension Group.

Pink rot *(Phytophthora erythroseptica)*

Symptoms

Pink rot infections generally begin at the stolon, causing buds and lenticels to turn black and dark coloured areas to form on the tuber surface. The skin covering infected areas is only loosely attached and can easily be rubbed off. Infected tubers do not change shape but become rubbery. When cut in half the tuber's exposed flesh will turn pink in half an hour then eventually black. Plants may wilt, with leaves turning yellow, rolling inwards, and dropping off. Darkly coloured stem and root lesions may also appear on susceptible varieties.

Transmission

Soil borne, this fungus can survive for long periods on decaying plant material and in soil. Pink rot infection usually occurs before or at harvest. Diseased tuber pieces can infect healthy tubers, and infected seed potatoes may transmit the disease if planted.

Notes

Pink rot develops in heavy, waterlogged soils particularly when heavy rains or excessive irrigation occur late in the season. Pink rot develops rapidly at temperatures of 20-30°C.

Symptoms of pink rot infection of a potato tuber.

Symptoms of pink rot infection of a potato tuber.

Powdery scab (*Spongospora subterranea*)

Symptoms

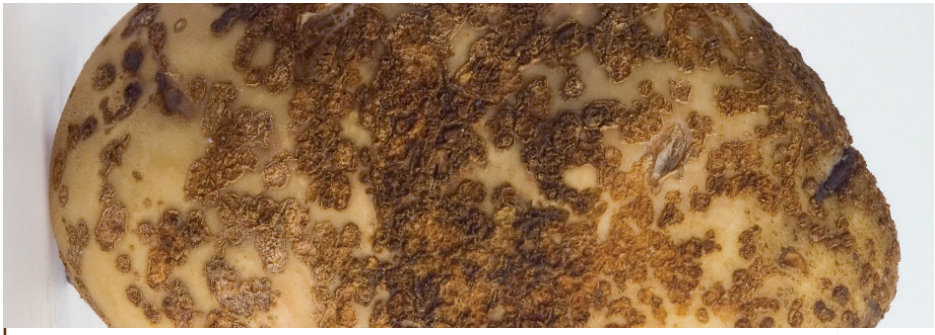
Powdery scab attacks below ground parts of the plant: roots, stolons, young shoots, and tubers. On tubers, powdery scab first appears as small pimple-like swellings on the skin surface. These gradually develop into lesions with frayed edges of scabby, upturned skin that may reach 20 mm across and can be filled with greenish, powdery spores. Skin may grow under the lesion causing the lesion to drop off, leaving a small depression. Powdery scab can continue to develop on tubers in storage, causing tubers to shrivel and dry up.

Transmission

Powdery scab may be introduced on infected seed potatoes but is also soil borne and can survive in the field for up to ten years. Powdery scab is the vector for Potato mop-top virus, an exotic disease recently detected in New Zealand.

Notes

Powdery scab is most prevalent under cool, moist growing conditions, and is often associated with poorly drained soils. It is difficult to differentiate common scab from powdery scab, so it is recommended that you seek a professional diagnosis.



A severe example of powdery scab symptoms on a potato tuber.
Image courtesy of Robert Lamberts, Plant & Food Research.

Close up of powdery scab symptoms on potato tuber skin.

Powdery scab symptoms on a potato tuber.
Image courtesy of Robert Lamberts, Plant & Food Research.

Sclerotinia rot/white mould (*Sclerotinia minor* and *S. sclerotiorum*)

Symptoms

Sclerotinia rot symptoms appear as soft, wet lesions on the stems just above the soil and on foliage which is in contact with the soil. These lesions can grow and eventually girdle the stem, causing the foliage to wilt but retain its green colour. Infected stems often turn yellow and will eventually collapse, and the entire plant may die – this can be mistaken for black leg, but Sclerotinia rot will not cause stems to turn black. Lesions are often covered in a white fungal growth dotted with black sclerotia, and sclerotia are also produced within the stem. Leaf infections appear as water-soaked, pale green lesions. Sclerotinia may also cause small, sunken lesions on tubers near the soil surface, with these lesions growing and turning black as a soft rot develops.

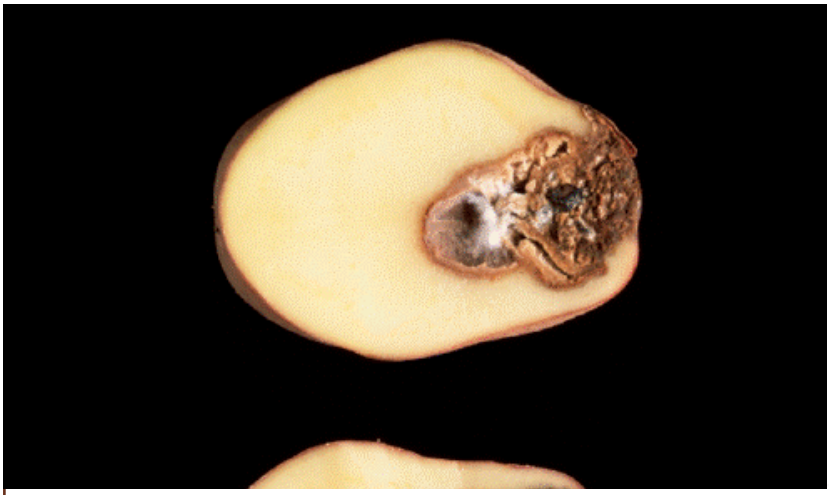
Transmission

Spores are released from sclerotia which can survive at least three years in soil.

Notes

This fungus attacks many other vegetables, legumes, and weeds.

Sclerotinia sclerotiorum



Sclerotinia sclerotiorum

Potato stem collapse caused by sclerotinia rot.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Sclerotium rot/stem rot *(Sclerotium rolfsii (telemorph Athelia rolfsii))*

Symptoms

Sclerotium rot or stem rot cause lesions at the base of potato stems. Plants may wilt during the day but recover at night, with infected plants often scattered through a field. Leaves may turn yellow and the stem can be girdled by the infection, which will eventually kill the plant. Typically, the fungus forms brown sclerotia which look like mustard seeds attached to the stem surface. Small, sunken lesions may form on tubers, and tubers may eventually be covered with threadlike, fan shaped fungal growth, and small spherical sclerotia may also form. The affected tuber eventually becomes rotted and has a cheesy texture.

Transmission

Sclerotium rolfsii survives for many years in the soil or in decaying plant tissue. The fungus spreads from infected tubers, plant debris or from contaminated equipment and containers. High temperatures and humidity favour the development of this disease.

Tuber symptoms of sclerotium rot – note the characteristic threadlike fungal growth.
Image courtesy of D. P. Weingartner. Reprinted by permission from the Compendium of Potato Diseases, 2nd ed., 2001, American Phytopathological Society, St. Paul, MN, USA.

Stem infection caused by sclerotium stem rot.
Image courtesy of McCain Foods (NZ) Ltd.

Silver scurf (*Helminthosporium solani*)

Symptoms

Silver scurf infection begins in the field with the disease becoming more severe in storage. Tubers develop circular, tan to grey lesions which grow and merge together, giving a superficial silvery discolouration. Symptoms are most clearly seen on clean, wet tubers. With advanced infection the skin may eventually slough off. Symptoms are often found on or near the tubers stem end. This disease does not cause any foliar symptoms and does not affect the yield, but water loss during storage may lead to a decrease in tuber weight and wrinkling.

Transmission

Spores produced on infected seed tubers may wash through the soil onto newly developing tubers, with infection taking place through lenticels and the skin. Silver scurf can also over-winter on decaying organic matter in soil, and fungus levels may build up if crops are not rotated.

Silver scurf symptoms.

Typical silver scurf symptoms on potato tubers.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Skin spot (*Polyscytalum pustulans* syn. *Oospora pustulans*)

Symptoms

Skin spot causes tan coloured lesions on potato roots, stolons, and lower stems. These lesions darken as they grow and may crack open. Affected tubers develop dark pimple–like spots approximately 2 mm across which may be grouped around the eyes and can eventually kill the developing buds. The disease may be invisible on tubers when they are harvested with symptoms often developing after 1-2 months in storage. Skin spot may delay plant emergence and cause uneven stands.

Transmission

The disease is primarily tuber-borne and initial infection is typically from infection of seed tubers. Skin spot may infect tubers through lenticels, eyes, and tuber wounds.

Notes

Skin spot is most commonly seen during cool, wet growing seasons. Heavier soils may also promote this disease.

Symptoms of skin spot on a potato tuber
Image courtesy of AHDB Potatoes, © Sutton Bridge CSR

Advanced symptoms of skin spot infection, with necrotic areas visible on the tuber's surface.
Source: http://potatoes.ahdb.org.uk/publications/r294-skin-spot-diagnostics
ADHB – Agriculture and Horticulture Development Board – potatoes

Stem end rot (*Phacidiopycnis tuberivora* (syn. *Phomopsis tuberivora*))

Symptoms

Stem end rot is a dry rot of tubers. This disease develops as a sunken, dry rot lesion at the stem end of the tuber, and the rot may grow to extend several centimetres into the tuber. A definite margin develops between the dry, crumbly, diseased tissue and healthy tuber tissues. In some instances, black fruiting bodies may also be visible on the tuber surface.

Transmission

Stem end rot appears to be soil borne.

Notes

Fungal spores penetrate tubers through wounds and abrasions. Infection tends to follow hot and dry weather.

Typical symptoms of stem end rot of a potato tuber.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Internal symptoms of stem end rot.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Verticillium wilt (*Verticillium albo-atrum* and *Verticillium dahliae*)

Symptoms

This disease is often seen as scattered patches throughout the field. First symptoms of Verticillium wilt usually occur on the lower leaves of the plant. The area between veins begins to yellow on one side of individual leaves or on only one side of a stem. Not all stems are affected, but infected leaves and stems become pale green to yellow, wilting and curling during the day but recovering at night. Plants may be stunted, and the crop may die early. The vascular tissues at the base of the stem may turn yellow or brown before becoming a blue-grey colour. On tubers, stem end discoloration may occur and there may be a light brown staining of the vascular ring of the tubers.

Transmission

Verticillium is soil-borne, surviving as long-lived sclerotia in the field for several years. *Verticillium* has a very wide host range and may also be introduced on infected seed potatoes.

Notes

Infections are most severe in warmer growing areas or seasons, and when plants are under heat, water, or nutrient stress.

Verticillium wilt foliar symptoms.
Image courtesy of Ontario Ministry of Agriculture, Food and Rural Affairs (OMFRA), © Queen's printer for Ontario, 2018. Reproduced with permission.

Symptoms of potato stem infection by Verticillium wilt, with brown vascular tissues visible.
Image courtesy of Lian Heng Cheah, Plant & Food Research.

Violet root rot *(Helicobasidium purpureum (syn. Helicobasidium brebissonii))*

Symptoms

Violet root rot occurs on both tubers and roots. It often causes the partial failure of stems, which may reach the surface but then rot below ground level. Stems which survive may become thickened and rosetted and grow slowly. In some cases, aerial tubers may form at the leaf axils. Tubers will generally be covered in small black sclerotia.

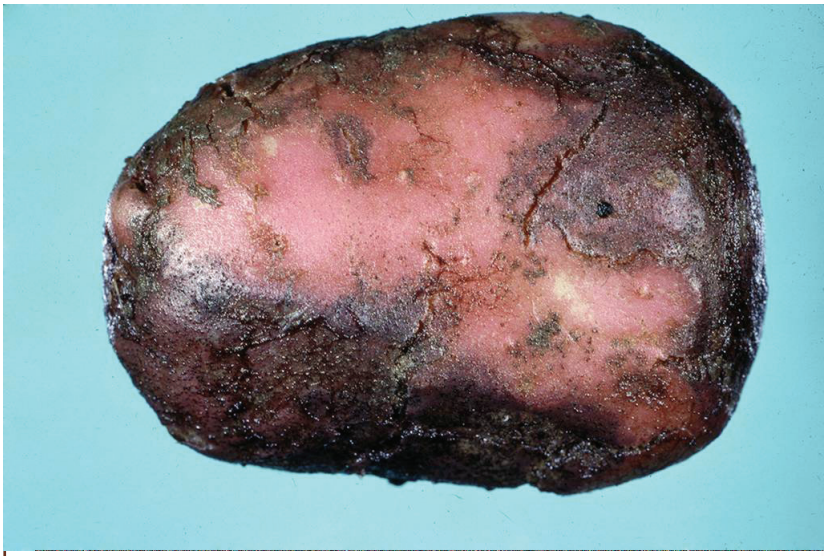
Transmission

Violet root rot is soil borne. The fungus may be spread as a contaminant on seed, plant parts, tools, floodwater, and equipment. It can survive as sclerotia in soil or on susceptible crop and weed hosts.

Notes

Violet root rot may occur more frequently when potatoes are planted in rotation with carrots. This disease can be a problem in soils which are sandy or peaty.

Symptoms of violet root rot of potato tubers showing areas covered in small black fungal bodies.
Image courtesy of Lian Heng Cheah, Plant & Food Research.



Violet root rot of a potato tuber.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

BACTERIA

Bacterial tuber soft rot *(Erwinia carotovora* subsp. *carotovora)*

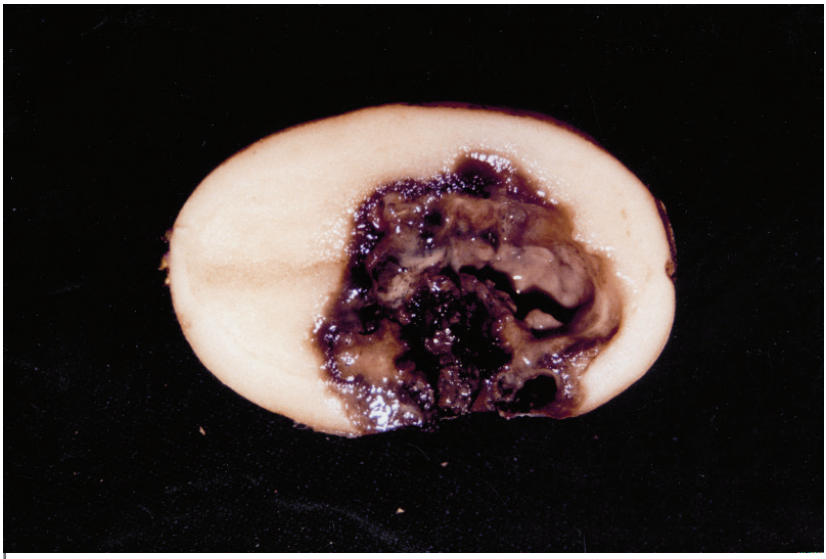
Symptoms

Symptoms of soft rot include rotted tissues that are wet, granular in texture, and cream to brown in colour. A black border may form around the infected tissue before total tuber collapse occurs. Infected lenticels can appear sunken and water-soaked. Bacterial tuber soft rot is odourless but secondary bacteria cause sliminess and a characteristic fishy smell. Soft rot can be spread through excessive condensation while tubers are in cool storage or when seed pieces are cut and stored.

Transmission

Bacterial tuber soft rot invades tubers mainly through wounds, bruises, or enlarged lenticels under cool wet conditions. Tubers infected with other diseases such as late blight or dry rot may also be invaded by this disease.

Symptoms of bacterial tuber soft rot on a potato tuber's surface. Infections may spread until then entire tuber turns soft and black.



Internal symptoms of bacterial tuber soft rot.
Image courtesy of Peter Wright, Plant & Food Research.

Black leg/black stem/aerial stem rot

(*Erwinia carotovora* subsp. *atroseptica* and *Erwinia carotovora* subsp. *carotovora*)

Symptoms

Black leg infection will often begin as a small, water-soaked spot on a tuber that rapidly grows to form a blister with a dark margin on the tuber's surface. Infected flesh is initially cream coloured but then turns grey-black and mushy, and a black border may occur between healthy tissue and infected tissue. Under cool wet conditions, infected tubers and their haulms may rot before emergence. Infected tubers can lead to stem infections which appear as a black decay extending up the stem. Infected stems become soft and slimy and eventually hollow out causing the stem to break. Plants may be more erect than is usual early in the season, and leaves may yellow and curl before the whole plant collapses. Secondary bacterial invasions can produce a fishy odour. Aerial stem rots may also start independently through natural openings and wounds, and infections can spread into daughter tubers which begin to rot in the field or later in storage.

Transmission

While the blackleg bacterium is naturally present in most soils, infected seed tubers are the primary source of infection.

Notes

Plants are particularly susceptible to black leg in cool, moist conditions. This disease may be recognised by its characteristic smell, and black leg is often a secondary infection following invasion by diseases such as dry rot or pink rot. Blackleg and aerial stem rot affect stems during the growing season, whereas soft rot affects tubers in the field and during transit and storage.

Black leg, which has spread from the tuber to the stem, causing a soft, black decay.
Image copyright Denis Crawford – Graphic Science, Australia.

Black leg of potato plant stems.
Image courtesy of John Fletcher, Plant & Food Research.

Common scab (*Streptomyces scabies*)

Symptoms

Common scab does not affect plant foliage. Symptoms on tubers may be superficial, deep pitted, or raised, but in all cases, it causes rough, corky brown scabs. Scabs tend to be 5-10 mm in diameter but may join together to form larger, irregularly shaped scabby areas. Different potato varieties show varied susceptibility to this disease. Symptoms of common scab can be mistaken for those of powdery scab, nematode infestation, or black scurf – if you are unsure seek a professional diagnosis.

Transmission

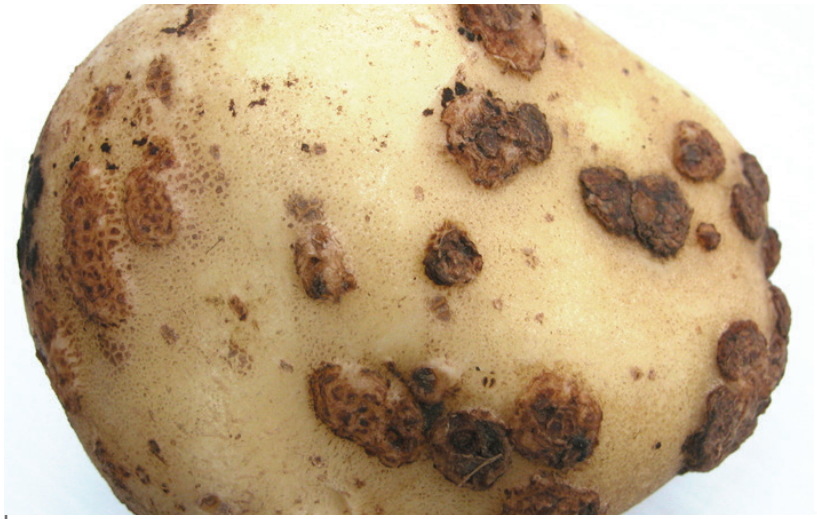
Common scab enters newly formed tubers through immature lenticels. Common scab is soil-borne and survives for long periods of time. It is usually spread through the planting of infected tubers.

Notes

Warm, dry summers can favour outbreaks of common scab. This disease affects the market quality of potatoes but does not have a significant impact on yield or storage.

Close up image of typical common scab symptoms.
Image courtesy of Robert Lamberts, Plant & Food Research.

Common scab symptoms on potato tubers.



Common scab symptoms on a potato tuber.
Image courtesy of Eugenia Banks, Plant & Food Research.

Zebra chip *(Candidatus* Liberibacter solanacearum, (Lso))

Symptoms

Symptoms of zebra chip on foliage are similar to psyllid yellows but are generally more severe. They include stunting, yellowing or purpling of the foliage, swollen nodes, upward rolling of leaves and formation of aerial tubers. Zebra chip can lead to widespread plant death. Underground symptoms include collapsed stolons and browning in the vascular tissue of the tubers. When the tubers are cut and fried, this browning appears as dark blotches or strips, hence the name zebra chip. This discolouration makes the potatoes unsaleable.

Transmission

Zebra chip is caused by plants being infected by the bacterium *Candidatus* Liberibacter solanacearum (Lso). This bacterium also severely affects other important solanaceous crops including tomato, capsicum, eggplant, tobacco and tamarillo. Zebra chip is primarily spread by the tomato potato psyllid (*Bactericera cockerelli*) feeding on infected plant hosts.

Lso field symptoms (Lia Liefting), Ministry for Primary Industries.

Zebra chip – J Munyaneza, USDA

INSECTS

Green peach aphid (*Myzus persicae*)

Description

Adult green peach aphids can be either winged or wingless. Wingless forms are more common at low population densities. Adult winged aphids have a black head and thorax, and a yellow-green or pink abdomen with dark bands. They are approximately 2 mm in length and the cornicles at the base of their abdomen (pair of small upright backward-pointing tubes found on the upper side of the last segment of the bodies of aphids) point slightly inwards, while those of potato aphids point outwards. Wingless adults are similar in size and range in colour from pale yellow to green to pink. Juvenile aphids are similar to wingless adults but are smaller in size.

Symptoms & Damage

The green peach aphid has a wide host range and is an important vector of plant viruses including Potato virus Y and Potato leaf roll virus. Depending on the virus, the aphid can be infectious for a few minutes or for much of its life. Feeding damage is rarely important and only occurs at high population densities when plants are weakened – virus transmission is the major concern.

Infestations of green peach aphid often begin on the lower leaves of potato plants, with the insects spreading up the plant as the population increases. Adults often fly short distances before landing to feed or lay eggs, and then flying on to another plant. This frequent movement between plants makes them particularly effective at spreading viruses through a crop.

Notes

Green peach aphid reproduction can be rapid with an entire life cycle taking place in as little as 12 days, so population growth can be rapid.

Winged adult green peach aphid.
Image courtesy of Corina Till, Plant & Food Research.

Wingless green peach aphid.
Image copyright Denis Crawford – Graphic Science, Australia.

Foxglove aphid (*Aulacorthum solani*)

Description

Foxglove aphids may be present in winged and wingless forms and tend to be around 3 mm in length. Winged foxglove aphids can be a light yellow-green, dark green, or orange, and may have black bands on their abdomens. Winged and wingless forms have distinctive dark leg joints and antennae joints and have a dark spot at the base of their cornicles.

Symptoms & Damage

Although found throughout New Zealand, the foxglove aphid is of little importance as it does not usually build up high populations in potatoes. This species can transmit plant viruses including Potato virus Y and Potato leaf roll virus and should be monitored along with other aphids found on potatoes.

Winged foxglove aphid, with distinctive dark joints on its legs and antennae.
Image courtesy of Robert Lamberts, Plant & Food Research.

Wingless foxglove aphid, with distinctive dark joints on its legs and antennae.
Image courtesy of Robert Lamberts, Plant & Food Research.

Hadda beetle *(Epilachna vigintioctopunctata)*

Description

Adult Hadda beetles are mostly orange coloured, although the colour does vary. They have around 26 black spots on their back and are 7-10 mm in size. The Hadda beetle should not be confused with the common lady bird that is found throughout New Zealand. Eggs are yellow, about 1.5 mm long and usually laid on the undersides of leaves in small batches of 5-40 eggs. The larvae are oval shaped, up to 6 mm in length and a yellow-green colour with black branchy thorns.

Symptoms & Damage

Adult beetles and larvae live openly on plants, eating the soft leaf tissues between veins. The presence of this pest can be readily detected by observing the lace-pattern damage to the leaves. Tapping infested leaves usually causes the beetle to fall to the ground. Hadda beetle is a field pest and does not usually occur in storage conditions, however adults may be accidentally transported in foliage or as hitchhikers on farm equipment.

Notes

Small populations of this pest were detected in January 2010 in Parnell and the Auckland Domain. It was subsequently found in wider locations in Auckland. It is now considered established in New Zealand.

Hadda beetle larva feeding.
Image courtesy of Nick Martin, © Plant and Food Research

Hadda beetle larva
https://waggabirds.files.wordpress.com/2010/03/00_i_epilachna_vigintioctopunctata_larva_1200.jpg

Hadda beetle adult
https://waggabirds.files.wordpress.com/2010/03/00_i_epilachna_vigintioctopunctata_1200.jpg

Potato aphid *(Macrosiphum euphorbiae)*

Description

Winged and wingless potato aphids may be found in the field. Wingless adults are pear-shaped and are 2-4 mm in length so tend to be larger than the green peach aphid. They can be light green or yellow-green in colour but can also be a reddish-pink. Winged adults have a yellowish-brown head and a green body. Dark pigmented legs and antennae distinguish this aphid from other species. Potato aphid cornicles point slightly outwards, in contrast to those of the green peach aphid which point inwards.

Symptoms & Damage

The potato aphid is found throughout New Zealand on potatoes and a wide range of other plants, and while this species does not often occur in large enough numbers to cause noticeable damage, it can be an important vector of Potato virus Y and Potato leaf roll virus. Potato aphids are often seen early in the season, and at high population densities may cause the upper leaves of some varieties to curl upwards, a symptom which may be mistaken for potato leaf roll virus.

Winged adult potato aphid.
Image courtesy of Robert Lamberts, Plant & Food Research.

Wingless potato aphid – note the two tubes at the rear of the insect, which are separate from its tail.

Mealybugs

(Pseudococcus calceolariae and Rhizoecus falcifer)

Description

Adult female mealybugs are the most commonly recognized life stage – they are about 3 mm long, have an oval body covered with powdery white wax, and are wingless. Adults have short antennae and legs that are not visible when viewed from above. Juvenile mealybugs are yellow to orangish to pink and initially lack wax. As they grow they develop their waxy coating and increase in size. The Citrophilus mealybug (*Pseudococcus calceolariae*) has a red body under the white wax while *Rhizoecus falcifer* has a translucent body under the wax – the two species can be distinguished by crushing an adult, as the Citrophilus mealybug's remains will be red. The adult males of both species are small delicate winged insects with long tail filaments. They are about 1 mm long and have wings but are rarely seen.

Symptoms & Damage

Mealybugs are usually found in groups or colonies. They feed on plant sap and secrete honey dew. Feeding can weaken plants and slow growth. *Rhizoecus falcifer* is more likely to be found on the plant roots and stems underground than on above ground parts of the plant. Mealybugs may also infest stored tubers.

Mealy bug nymphs. Image courtesy of Asure Quality Ltd.

Adult female mealy bugs. Image copyright Denis Crawford – Graphic Science, Australia.

Tomato potato psyllid *(Bactericera cockerelli)*

Description

Adult psyllids look like tiny cicadas around 2-3 mm in length. They have a black body with two white stripes on the abdomen and clear wings over their body. Immature adults are a pale cream colour before developing the darker markings. Psyllid nymphs are flat and pale yellow to green with a fringe of hairs around the edge. Nymphs resemble scale insects feeding on the underside of leaves, but unlike scale insects they may move a few millimetres if disturbed. Psyllid eggs are yellow and are attached to the plant by a thin stalk. They are laid singly on the leaves and stem of the host and are often found on the leaf edge.

Symptoms & Damage

Tomato potato psyllids nymphs and adults feed by sucking plant sap. Nymphs secrete honeydew that is deposited as a grainy, sugar-like substance on leaves. Plants infested with psyllids may exhibit a disease known as psyllid yellows. Plant symptoms of psyllid yellows include stunting and yellowing of the growing tips, yellowing or reddening/purpling of leaves which may be cupped and an overall reduction in plant growth.

Tomato potato psyllid is the main vector for a bacterium called *Candidatus* Liberibacter solanacearum. This bacterium causes a disease known a zebra chip. Above-ground plant symptoms of zebra chip are similar to that of psyllid yellows except that zebra chip causes more severe foliar symptoms which can lead to plant death. The plant stem may also have swollen nodes and a browning of the vascular system. Developing tubers may be smaller or may have the starch levels in tubers reduced. This reduction in starch levels can cause dark streaking to occur in the potatoes when they are cooked, hence the name zebra chip.

Notes

The tomato potato psyllid has become widespread in New Zealand, affecting all potato growing areas throughout the North and South Island.

Tomato potato psyllid adult
Image copyright United Nations, 2014 UNECE (ECE/TRADE/416) 2014. © NDSU/Gudmestad

TPP eggs, nyphs and adult on leaf
Whitney Cranshaw, Colorado State University, Bugwood.org (http://www.forestryimages.org/browse/detail.cfm?imgnum=1243127)

Tomato potato psyllids – immature adults (left), mature adult (centre), nymphs (right).
Image courtesy of Department of Primary Industries and Regional Development, WA © State of Western Australia

Potato tuber moth

(Phthorimaea operculella (syn. Gnorimoschema operculella))

Description

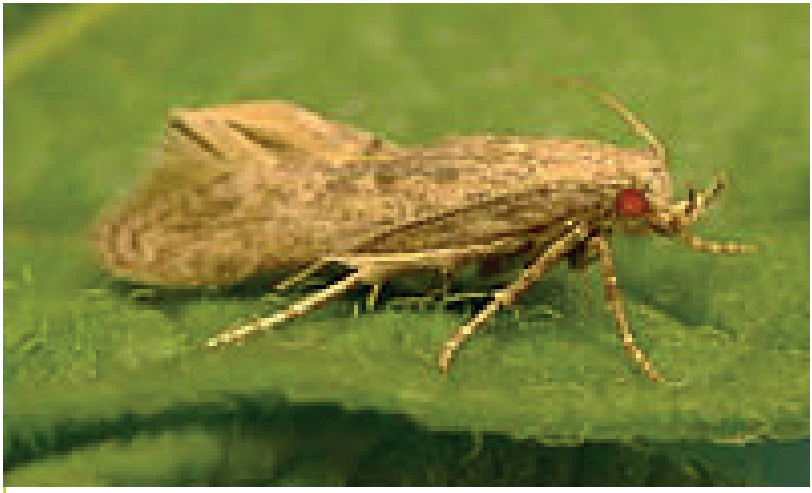
Adult potato tuber moths have a slim, silver-grey body and grey-brown wings covered with dark specks. They are approximately 10 mm in length, have a wingspan of 12 mm and are active mainly at dusk. White eggs are laid on the underside of potato leaves and on exposed tubers. Newly hatched larvae are 1-2 mm long, but grow to a length of 15-20 mm. Larvae can be grey, yellow-white, or slightly pink or green, but all have a dark brown head.

Symptoms & Damage

The larvae bore into potato leaves, stems, and tubers and can be a major pest of potatoes and other Solanaceous plants. Larvae feed inside the leaves, often following veins. This species often invades plants at the end of rows first, before moving deeper into a crop. Damage to tubers can be recognised by small mounds of dark, sawdust-like frass at the tunnel entrances. Potato tuber moth can also be a problem in stored potatoes.

Notes

The potato tuber moth can complete its life cycle in four weeks in mid-summer but this can take several months in cooler weather.



An adult potato tuber moth.
Image copyright http://cropwatch.unl.edu/potato/tubermoth

Damage by potato tuber moth
Image copyright United Nations, 2014. UNECE (ECE/TRADE/416) 2014. © SASA

White fringed weevil

(Naupactus leucoloma (syn. Graphognathus leucoloma))

Description

Adult white fringed weevils are flightless and approximately 13 mm in length with a white line along the wing case. The white eggs are laid on the ground in January or February, and when the larvae hatch, they burrow into the soil where they spend the winter feeding on plant roots and growing to around 15 mm in length. Mature larvae are cream coloured and quite solid in appearance, with no legs. The larvae's pale coloured head is not obvious, only distinguishable by the black mouthparts that are seen protruding.

Symptoms & Damage

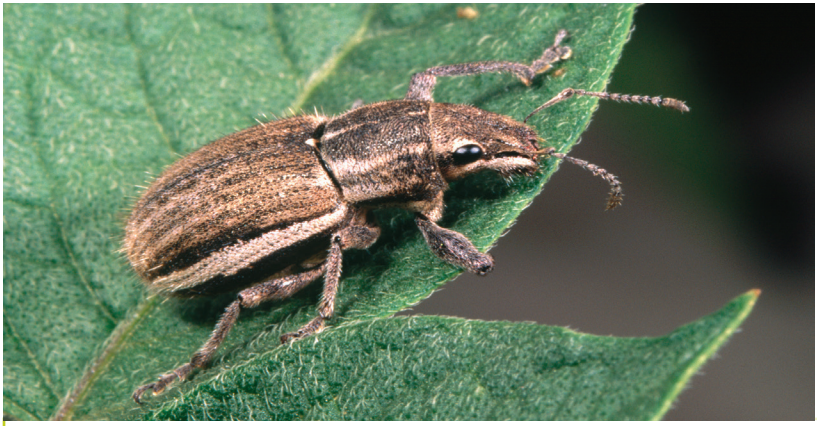
Larvae generally feed on plant roots and underground stems but may also chew holes or shallow channels in potato tubers. This species has a wide host range.

Notes

This species is a pasture pest in light soils especially in the North Island and is a particular problem in potato crops that have been planted in what was previously pasture. Crop rotation may provide some control of this species.

White fringed weevil larvae.
Image courtesy of Nicholas Martin, Plant & Food Research.

A white fringed weevil larva emerging from a potato tuber, with its black mouthparts clearly visible.
Image copyright Denis Crawford – Graphic Science, Australia.



Adult white fringed weevil.
Image copyright Denis Crawford – Graphic Science, Australia.

Wireworm *(Family Elateridae, several species)*

Description

Wireworms are the larvae of click beetles. The larvae are long and cylindrical, generally a pale yellow or brown colour, and are shiny. They have a hard, jointed bodies and can be up to 30 mm in length. Adult click beetles are brown or black, approximately 15 mm long, and slightly flattened. The adults are easily recognised by the distinctive click they make when jumping if they are disturbed.

Symptoms & Damage

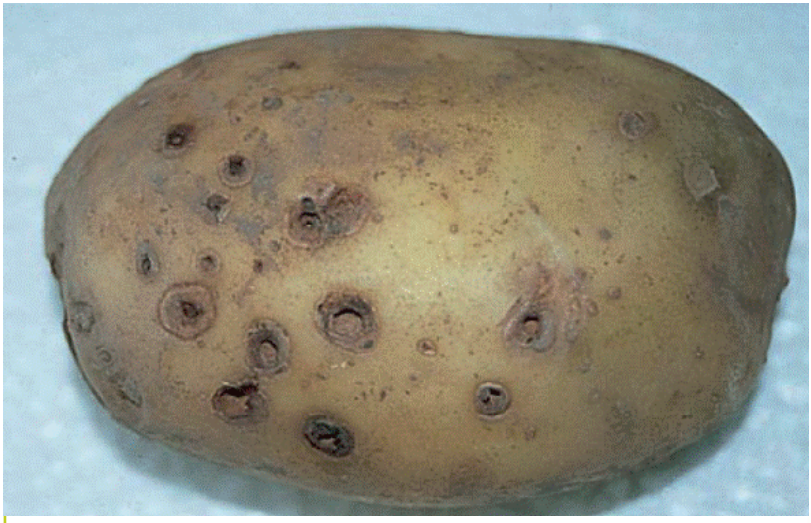
Wireworm larvae cause chewing damage to roots and holes in tubers. The damage caused by wireworm larvae can allow secondary fungi and bacteria to attack the plant.

Notes

The wireworm's life cycle can take many years and a single generation may live in the soil for up to five years. Not all wireworm species are damaging to potatoes.

Adult wireworm
Image © Entomart https://www.growveg.co.uk/pests/uk-and-europe/wireworm-click-beetle/

Wireworms



Wireworm holes

NEMATODES

False Columbia root knot nematode *(Meloidogyne fallax)* and Northern root knot nematode *(Meloidogyne hapla)*

Symptoms

False Columbia root knot nematode rarely causes above ground symptoms unless there is a heavy infestation. This can cause plants to be stunted, with leaves turning yellow before wilting and dying. Small wart-like galls are produced on plant roots. On tubers, small pimple or blister like galls form either singly or in groups on the surface, and brown spotting develops in the vascular ring. Tubers can dehydrate under heavy infestations.

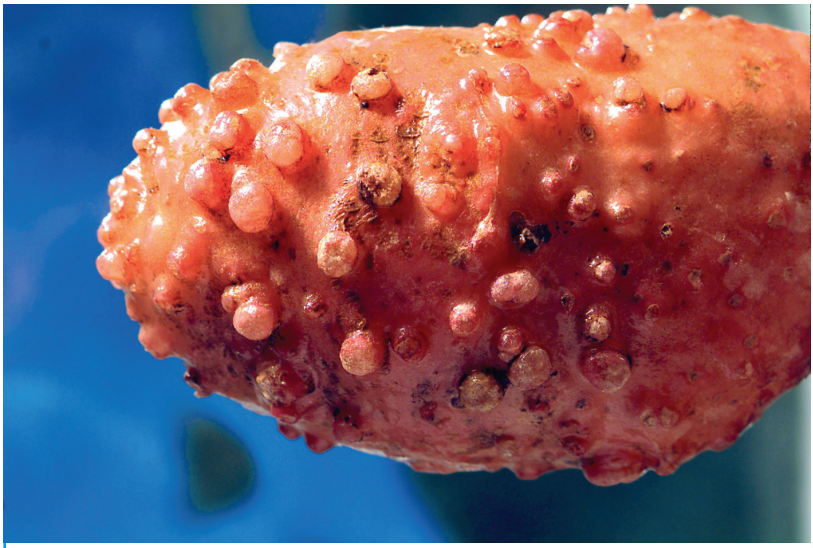
Northern root knot nematode often causes similar symptoms including impaired root function, stunting, discolouration, or even death of plants. Small galls occur on roots, and unlike the false Columbia root knot nematode, these galls cause a large number of lateral roots to develop. Like the false Columbia root knot nematode, it causes brown spotting inside tubers, but while the tubers may swell, there is no formation of pimple or blister like galls on the tuber surface.

Transmission

Root knot nematodes overwinter as eggs or as juveniles in the soil or in plant tissue, including tubers. Unlike many root knot nematodes, the Northern root knot nematode can withstand cold, with eggs and juveniles surviving field temperatures below 0°C. However, this species seems to be less tolerant of high temperatures.

Notes

Root knot nematode damage is sometimes confused with powdery or common scab infection. If in doubt, seek a professional diagnosis.



Pimple-like galls on a potato tuber, symptoms of false Columbia root knot nematode infestation.
Image courtesy of Farhat Shah, Plant & Food Research.

Brown spots approximately 6 mm beneath the skin of a potato tuber, a symptom of false Columbia root knot nematode and northern root knot nematode infestation.
Image courtesy of Farhat Shah, Plant & Food Research.

Potato cyst nematode

(Globodera pallida and G. rostochiensis)

Symptoms

Infestations of potato cyst nematodes often occur without causing above ground symptoms. However, they can cause plants to be stunted, have poor growth and cause premature plant death. Infected plants may wilt, and often have spindly stems with stunted or pale foliage. Small cream or brown coloured cysts form on potato roots when female nematodes burrow into root tissue. The root systems of infected plants may be poorly developed, and tubers may be distorted or small in size, with yields decreasing as infection rates increase.

Transmission

Potato cyst nematodes invade the roots and reduce the host's ability to transport water and nutrients. Infection can be patchy in a crop, but losses can reach up to 70%. At particularly high nematode densities, cysts may be seen on the surface of the potato tubers later in the growing season as well as on the roots around flowering. Mature cysts become dark brown or golden in colour.

Notes

Nematode cysts can remain viable in the soil for up to 20 years and may be carried in infected soil, attached to tubers or farm machinery. At very high levels of infestation the potato cyst nematode may invade tubers, and these then become a further source of infection.

Microscopic view of the potato cyst nematode.
Image courtesy of Ulrich Zunke, University of Hamburg, www.forestryimages.org

Potato cyst nematode cysts on potato roots.
Image courtesy of Farhat Shah, Plant & Food Research.

Potato rot nematode *(Ditylenchus destructor)*

Symptoms

The potato rot nematode causes no above-ground symptoms in potatoes. The first symptoms to appear on tubers are small, white spots just below the skin (visible if cut or peeled). Infection causes patches of the tuber's tissues to become dry and grainy, gradually darkening as fungi and bacteria attack these regions. The tuber's skin will become thin and papery and may start to crack as the underlying tissues dry out and shrivel. The blemishes inside the tuber may grow until the entire tuber is mummified, which may occur in storage.

Infection

In the resting stage, the nematode can persist in soil and can be transmitted to new sites by movement of infected soil or infected seed tubers.

Notes

Note that the potato rot nematode is present in New Zealand and has been reported infecting other crops, but it has not been formally reported on potatoes in this country – please report any suspected infections of this pest to Potatoes NZ.

Ditylenchus destructor

Stem and bulb nematode *(Ditylenchus dipsaci)*

Symptoms

Unlike most other nematodes which invade potatoes, the stem and bulb nematode can develop in the leaves as well as the stems and tubers. Infection with this nematode may cause affected above ground parts of potato plants to be swollen or distorted. Growth of the plants is slowed, and necrotic lesions can form on tubers and stems. Secondary bacterial and fungal infections may disguise the nematode's presence.

Transmission

Stem and bulb nematodes can be transmitted in infected seed tubers. Juvenile nematodes can gather on or just below the surface of heavily infested tissue to form clumps of 'eelworm wool'. Stem and bulb nematodes usually invade their hosts through natural openings, and then move through the plant destroying cell walls and feeding on cell contents. They have a wide host range but are most commonly associated with bulbs such as onions. Cool, moist conditions favour invasion of young plant tissue by this nematode.

Notes

Stem and bulb nematode is not particularly common in potatoes, and infestation may be patchy in a crop. This nematode can survive in the soil for at least eight years.

Eelworm wool, a symptom of stem and bulb nematode infestation.
Image courtesy of Central Science Laboratory, Harpenden Archives, British Crown, www.insectimages.org

Stem swelling and distortion caused by stem and bulb nematode infestation – note that this image is of infested horsebean, but similar symptoms are seen in potato.
Image courtesy of Dr. Augustin, Landesanstalt für Pflanzenbau und Pflanzenschutz: Mainz, www.insectimages.org

Many viruses have similar symptoms, so it can be difficult to distinguish them in the field. For this reason, only the more common viruses are covered in the handbook.

Aucuba and calico

(Potato aucuba mosaic virus (PAMV) and Alfalfa mosaic virus (AMV))

Symptoms

PAMV causes yellow spotting of foliage, as well as tuber necrosis in some varieties of potato. AMV, also known as calico, causes bright yellow blotches on leaves as well as stunting of the plant. Some strains cause leaf deformation as well as necrotic, dry, or rust brown patches in tubers.

Transmission

Both viruses are transmitted by aphids feeding or through plant to plant contact. These diseases are of little economic importance in New Zealand potatoes.

A example of severe calico symptoms, caused by the relatively uncommon alfalfa mosaic virus. Image courtesy of John Fletcher, Plant & Food Research.

Latent viruses

(Potato virus M (PVM) and Potato virus S (PVS))

Symptoms

Obvious plant symptoms are rarely seen as a result of infections with these viruses as most potato varieties can be symptomless carriers. Subtle changes in plant shape or habit can be observed under certain weather conditions. Infection may reduce the yield of some varieties by up to 20% when these latent viruses occur in combination with other viruses such as Potato virus X, Potato virus Y, or Potato leafroll virus.

Transmission

Latent viruses are transmitted by aphids or through plant to plant contact. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

Mild mosaic viruses

(Potato virus A (PVA) and Potato virus X (PVX))

Symptoms

Mild mosaic viruses usually cause a mild mosaic or mottle of potato leaves. In some susceptible varieties, and where there is tuber-borne infection or a mixed virus infection, plants may become stunted and may develop severely wrinkled or puckered leaves.

Transmission

Potato virus A is transmitted by aphids, while Potato virus X is transmitted through plant to plant contact. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

Notes

These viruses are generally considered to be of minor economic significance in New Zealand.

Mild mosaic virus symptoms.
Image courtesy of John Fletcher, Plant & Food Research.

Potato leafroll virus *(PLRV)*

Symptoms

The type and severity of symptoms depends on when the plant was infected with leafroll virus. Plants grown from infected tubers generally have more severe symptoms compared to plants infected during the growing season. Infected tuber grown plants show their symptoms on the lower leaves first. Leaves roll upwards, have a stiff, leathery texture and may die. Plants can be stunted and may show a stiff, upright habit of growth. In contrast, plants infected during the growing season show their symptoms on younger leaves first. Affected leaves become pale in colour and roll upwards and inwards and often have a purple margin. Potato leafroll virus may also cause tuber net necrosis in some potato cultivars.

Transmission

Potato leafroll virus is transmitted by aphids such as green peach aphids and potato aphids. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

Notes

Leaf rolling can also be caused by environmental stresses and other diseases such as black scurf, so a professional diagnosis may be necessary.

Potato leafroll – in this photo the leafroll is a symptom of potato leafroll virus, but it may also be caused by several other viruses, diseases such as black scurf, and environmental conditions.

Potato virus Y^N *(tobacco veinal necrosis strain (PVY^N))*

Symptoms

This strain of Potato virus Y^N may be virtually symptomless when initial infection occurs, though sometimes a very mild mosaic may be seen. If infected seed is planted, a mild mosaic may persist, and plants may be stunted. In New Zealand, tuber symptoms may develop from this strain of PVY – symptoms include brown spotting, superficial blistering, cracking, and necrosis of the tubers. These symptoms often develop during storage, particularly at higher temperatures.

Transmission

Potato virus Y^N is transmitted by several species of aphid and occasionally through plant to plant contact. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

Notes

PVY and PVY^N can cause losses of up to 40% but these viruses are generally considered to be of minor economic significance if high health seed tubers are planted.

Ringed necrotic areas cause by potato virus Y^N.
Image courtesy of John Fletcher, Plant & Food Research.

Rugose mosaic virus *(Potato viruses X and Y)*

Symptoms

Potatoes infected by both Potato virus X and Potato virus Y can develop symptoms of plant stunting, leaf mosaic, and rough, wrinkled (rugose) leaves. Where there is tuber-borne infection, plants may emerge severely stunted and with severely rugose leaves. If PVY^N is present, tuber necrosis may also occur. Mixed infections such as this tend to cause greater yield losses than infections with only a single virus.

Transmission

Potato virus Y is transmitted by aphids and Potato virus X and via plant to plant contact. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

Rugose mosaic symptoms caused when a potato plant is infected by both X and Y viruses.
Image courtesy of John Fletcher, Plant & Food Research.

Severe mosaic virus *(Potato virus Y (PVY))*

Symptoms

Severe mosaic virus causes a range of symptoms including plant stunting, mild to strong leaf mottle or mosaic, leaf crinkling, necrotic veins, necrotic leaf spots, and leaf dropping. Tubers do not appear to show symptoms, but yield is reduced.

Transmission

This virus is transmitted by several species of aphid such as green peach aphid and potato aphid and occasionally through plant to plant contact. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

Severe mosaic virus symptoms can be seen in the left hand plant pictured here, with a healthy plant to the right.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries, Lincoln.

Hollow heart

Description

Hollow heart is an irregular hole inside the potato tuber. It is sometimes star-shaped and can occur in the centre of the tuber or towards one end. The internal walls are white or light brown and are not decayed.

Causes

Hollow heart is caused by sudden changes in growing conditions which result in the plant growing too quickly, pulling the insides of the tuber apart. This often occurs when the plant recovers too quickly from environmental or nutritional stress, such as following a dry or cold spell.

Hollow heart. Image courtesy of McCain Foods (NZ) Ltd.

Internal black spot

Description

Symptoms of internal black spot are round or irregular shaped brown or black flecks scattered throughout the flesh of potato tubers. These small lesions are typically around 3 mm across.

Causes

Internal black spot is commonly caused by a deficiency in nutrient and/or water during tuber development as an interruption in supply may cause young tissues to die.

Internal black spot symptoms in a potato tuber.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries, Lincoln.

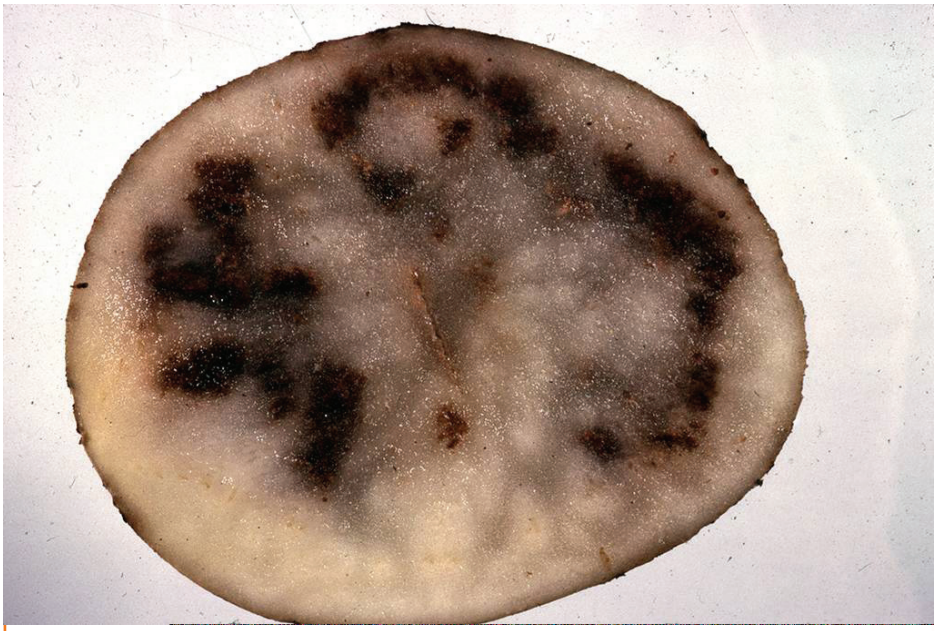
Internal heat necrosis

Description

A brown or black necrosis of the tuber's central vascular tissue, visible when the tuber is cut in half.

Causes

This disorder develops when tubers are exposed to extremely high soil temperatures in the later stages of tuber growth, while the stems are still alive. Heat necrosis is most commonly seen in tubers growing near the soil surface.



Internal heat necrosis in a potato tuber.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Stem end browning/vascular necrosis

Description

This disorder causes a tan to reddish brown discoloration at the stem end of the tuber. This discolouration does not usually extend more than 1 cm into the tuber's flesh.

Causes

Stem end browning occurs when the potato tops are killed rapidly by herbicides, frosts, or vine pulling. The disorder is particularly prevalent when this occurs under very dry conditions. Tubers infected with potato leafroll virus or verticillium wilt may also exhibit symptoms similar to stem end browning.

External symptoms of stem end browning.
Image courtesy of the National Institute of Agricultural Botany, Cambridge, UK.

Internal symptoms of stem end browning.
Image courtesy of the National Institute of Agricultural Botany, Cambridge, UK.

Tuber greening

Description

Potato tubers which have been exposed to light commonly develop a green colouration. The green pigment is chlorophyll – this in itself is harmless, but other compounds also increase in tissues exposed to light, and these can be toxic while giving the potato a bitter taste.

Causes

The exposure of tubers to sunlight, indirect daylight, or artificial light enhances chlorophyll production in the tuber's skin. Greening occurs most rapidly at temperatures above 13°C.

Tuber greening symptoms.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

SECTOR RISK ORGANISMS (SROs)

Sector Risk Organisms (SROs) are unwanted pests and diseases (biosecurity threats) that could damage New Zealand's primary industries, negatively impacting on production, profitability, competitiveness, the environment and our way of life. Any sighting of these should be reported to MPI immediately on 0800 80 99 66. Several of the pests and diseases listed here are quite similar to related species which already occur in New Zealand – if you have any doubt, please contact MPI.

Potato wart *(Synchytrium endobioticum)*

Symptoms

Potato wart is a serious fungal disease, causing galls on tubers, stems, and occasionally on potato foliage. These galls can range from barely visible warts no larger than a pinhead, to large, cauliflower-like lumps that engulf much of the plant.

Notes

This disease has been found in New Zealand but has only ever been reported from home gardens in Southland and has never been seen in commercial crops. All detections of potato wart have been eradicated.

Potato wart

Galls on a potato tuber caused by the potato wart pathogen.
Image courtesy of Plant and Environment Laboratory, Ministry for Primary Industries.

Galls on a potato tuber caused by the potato wart pathogen
Image courtesy of Fera Science Ltd https://fera.co.uk/

Potato ring rot

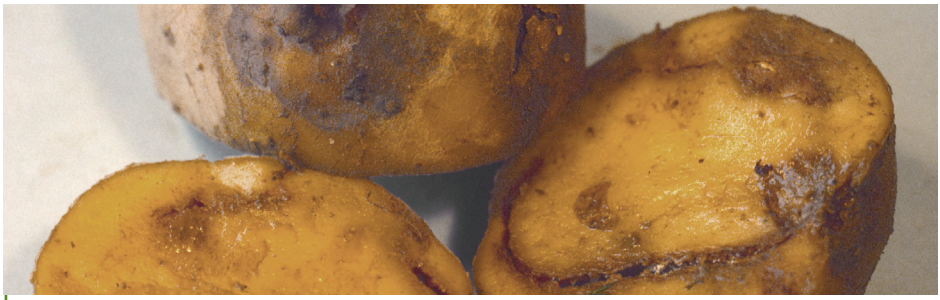
(Clavibacter michiganensis subsp. sepedonicus)

Symptoms

Potato ring rot causes wilting of potato leaves and stems after mid-growth, with the lower leaves affected first. Leaves may become pale green with yellowing between veins and slight rolling at the leaf margins. More pronounced wilting, loss of colour along the veins of leaves, and leaf necrosis may be seen as the disease progresses. This is followed by further rolling of the leaves and the development of necrotic, brittle leaf margins. Plants may be symptomless under cool wet conditions. If the stem is cut near the base, a milky fluid can be squeezed out. Tuber symptoms include a yellow or light brown cheesy rot around the vascular ring. The vascular tissue may separate from surrounding tissues, and the decay can extend to the outer surface of the tuber which will appear sunken and cracked. Tubers may eventually disintegrate completely.

Transmission

Potato ring rot is extremely infectious and is mainly transmitted through seed potatoes. While this disease does not over-winter in the soil, it can survive for two or more years on cutting equipment, bins, bags, and other equipment.



Tuber symptoms of potato ring rot, showing a pronounced rot around the vascular ring and separation from surrounding tissues.
Image courtesy of Rosemary Loria, Cornell University.

Potato ring rot.

Bacterial wilt/brown rot/milky eye/ mattery eye

(Ralstonia solanacearum)

Symptoms

Bacterial wilt/brown rot causes rapid and premature wilting of the foliage, followed by darkening of the veins and vascular tissues, and plant death. Leaves may discolour or may remain green during wilting, only losing their colour once the plant dries out. A single stem may wilt at first, but others often follow. If cut at the base, stems exude a whitish bacterial slime distinguishing this disease from wilts caused by fungi. Infected tubers often have grey-brown vascular tissues visible when the tuber is cut. The eyes of infected tubers often turn grey-brown, and bacterial slime may leak or be squeezed out – hence the term 'milky eye'. Symptoms can occur at any stage of plant growth.

Transmission

Bacterial wilt/brown rot is often spread through infected seed potatoes and may also be soil-borne. This disease can also be spread through contaminated irrigation water, soil, equipment, and personnel. Solanaceous weeds and crop plants can also harbour the disease.

Notes

Note that there are several races of this disease, but only races 1 and 3 are present in New Zealand and are not widespread. As it is difficult to distinguish between the races, any outbreaks of brown rot should be reported to MPI.

Ralstonia solanacearum

Milky eye symptoms on a potato tuber. Note the milky bacterial ooze coming out from the tuber's eyes.

Late blight A2 mating strain

(Phytophthora infestans)

Symptoms

Symptoms of late blight A2 mating strain are the same as those of the late blight strain currently found in New Zealand (A1 strain) – small dark spots on leaves which expand into large lesions on leaves and stems, and can cause total plant collapse. The main difference between the strains is that the A2 strain can result in more severe symptoms that spread faster than the current A1 strain. This is because the A2 strain can mate with the A1 strain to produce a stronger, more genetically diverse pathogen. Disease outbreaks resulting from this may build up resistance to pesticides more quickly and may be difficult to control.

Transmission

The late blight strain that is currently in New Zealand produces spores which must be spread through infected host tissue (mainly infected tubers or volunteer plants). The A2 strain of late blight can combine with the current strain to produce spores that do not require host tissue to spread. These spores can survive in the soil without a host from season to season. This makes control of the disease much more difficult.

Late blight symptoms on potato leaf.
Image courtesy of Dr Jean Beagle Ristaino, Dept of Entomology and Plant Pathology, NC State University http://www.usablight.org/

Late blight symptoms on potato stem.
© Bruce Watt, University of Maine

Black leg disease *(Dickeya solani, formerly Erwinia chrysanthemi)*

Symptoms

Symptoms caused by black leg may vary depending on the variety. Symptoms include initial wilting of top leaves, wilting of lower leaves followed by desiccation of foliage, external darkening of the stem base, and discolouration of the vascular system in the stem base. Wilting can be rapid with black, soft rotting extending internally up the vascular system of the stem from the infected seed tuber.

Transmission

The most important means of spread for black leg is the movement infected potato seed tubers. Spread of the disease through Europe is thought to be via this pathway. Black leg can be spread by physical contact or contamination of machinery and equipment during cultivation, harvesting and grading, and possibly environmental contamination.

Where black leg is present, control measures include avoidance of mechanical harvesting to reduce tuber damage, cleaning, and disinfection of machinery.

Notes

Observations from European countries indicate that once established, black leg will rapidly displace other species and take over as the principal cause of wilting and blackleg-like symptoms in potato crops. Most direct losses to potato production in Europe caused by black leg have occurred as a result of downgrading or rejection of potatoes during seed tuber certification.

Dickeya

Dickeya – foliar symptoms

Dickeya – foliar symptoms

Columbia basin purple top phytoplasma

(Candidatus phytoplasma spp.)

Symptoms

Phytoplasmas are a group of bacteria-like organisms that can cause disease in a wide range of plants. Columbia basin purple top phytoplasma is part of a group of phytoplasmas that cause purple top symptoms. In potatoes this can be seen as a purpling of the young leaves and growing tips of the plant. Infected leaves tend to roll upwards, and overall plant growth may be stunted. Aerial tubers may be produced, reducing the size and overall yield of the plant.

Transmission

Phytoplasmas are mostly transmitted by insects. The main insects involved in transmitting phytoplasmas from the *Candidatus* species are planthoppers. There is some debate over whether phytoplasmas can be transmitted through infected potato tubers, but studies show this can happen to some degree.

Symptoms of Candidatus spp. phytoplasma infection in potatoes. Note the rolling of leaves and the purple colour on the young growing tip.
Image courtesy of K.B. Simoglou, Department of Quality and Phytosanitary Inspections (Rural Economy and Veterinary Directorate of Drama), Greece

Potato stolbur phytoplasma *(Candidatus phytoplasma solani)*

Symptoms

Potato stolbur phytoplasma symptoms include leaf rolling of young leaves, reddening or purpling of the leaves and growing tips, shortened internodes, and aerial tuber formation. This disease can also cause the flesh of the tubers to brown when fried, making the tubers unmarketable.

Transmission

Phytoplasmas are mostly transmitted by insects. The main insects involved in transmitting phytoplasmas from the *Candidatus* species are planthoppers. There is some debate over whether phytoplasmas can be transmitted through infected potato tubers, but studies show this can happen to some degree.

Foliar symptoms of potato stolbur phytoplasma.
Image courtesy of K.B. Simoglou, Department of Quality and Phytosanitary Inspections (Rural Economy and Veterinary Directorate of Drama), Greece

Aerial tuber formation on a plant infected with potato stolbur phytoplasma.
Image courtesy of K.B. Simoglou, Department of Quality and Phytosanitary Inspections (Rural Economy and Veterinary Directorate of Drama), Greece

Brown Marmorated Stink Bug (BMSB)

(Halyomorpha halys)

Description

Adult BMSB are large (approximately 1.7 cm long) with a distinctive brown "shield" shape and are a brownish grey colour. Their underside is white/tan and their legs and antennae are brown with white banding. Egg clusters (20-30 eggs) are laid on the underside of leaves. BMSB has five nymphal stages, or instars, and range in size from 2.4 mm to 12 mm in length. The nymphs are yellowish brown mottled with red and black. The first instars, which have a "tick-like" appearance, are not very active and remain around the hatched egg mass. Nymphs are characterized by dark reddish eyes and a yellowish-red abdomen that is also striped with black.

Adult BMSB are strong fliers and will disperse when disturbed. They emit a strong, long lasting odour when disturbed or crushed. Adults seek concealed, cool, tight, and dry locations to overwinter. Because of this overwintering behaviour, many suitable sites are available such as inside cardboard boxes, shipping containers and luggage, between wooden boards, within layers of folded tarps, and within machinery motors and vehicles.

Symptoms and Damage

BMSB will feed on a wide range of horticultural crops causing direct injury which can result in significant crop losses. The extent of damage can vary by crop. They can also be a nuisance in rural and urban houses where they may go to seek shelter during the autumn and winter months.

Notes

Overwintering BMSB have been intercepted in New Zealand on vehicles and within shipping containers imported from the USA, Italy and Asia.

Adult BMSB
(http://www.stopbmsb.org/stopBMSB/assets/Image/BMSB-on-bark-istock350w.png)

BMSB nymphs, first instar, cluster around a mass of newly-hatched eggs on the underside of a leaf.
Photo by W. Hershberger http://www.stopbmsb.org/stopBMSB/assets/Image/BMSB_Figure1_9852.jpg

Leaf mining flies *(Liriomyza sativae, L. bryoniae, L. trifolii; L. huidobrensis; L. nietzkei, L. cepae, Chromatomyia horticola, Phytomyza gymnostoma)*

Description

Leaf mining flies are small (1.0 to 2.5 mm long) flies with a compact body which is greyish-black and yellow in colour. Larvae are typical maggots, up to 3 mm long and whitish. In some species the maggots are bright yellow or yellowish-green.

Symptoms and damage

The adult females carry out numerous punctures into the leaf surface for egg laying as well as for feeding on the sap that leaks from the injured leaf tissue. The feeding-points appear as white-yellow dots all over the upper surface of leaves. Eggs are laid just beneath the surface of the leaf. On hatching, the larvae "mine" the leaf, hence the name leafminer. Most damage is caused by larval feeding. The larvae will tunnel through the leaves, leaving the outer layer intact, thereby producing characteristic, unsightly mines. Heavy infestations can slow down plant development and can lead to total crop losses.

Leaf mining species attack a wide range of ornamental and vegetable crops and transportation of these plants can contribute to their spread. Transporting eggs, larvae and pupae in produce or soil is the primary means by which leaf mining flies have been widely dispersed.

Lyriomyza trifolii
Central Science Laboratory, Harpenden, British Crown, Bugwood.org. Forestry Images.org (http://www.forestryimages.org/browse/detail.cfm?imgnum=0660020)

Lyriomyza damage on potato leaf Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org (http://www.insectimages.org/browse/detail.cfm?imgnum=5368099)

Potato Flea Beetle

(Epitrix spp. – E. similaris, E. papa, E. tuberis, E. cucumeris, E. subcrinita)

Description

Adult flea beetles are approximately 2 mm long and are metallic green to brown/black in colour. They have large back legs and jump like fleas when disturbed. Larvae live in the soil. They are slender, whitish in colour and approximately 6 mm long when fully grown.

Symptoms and damage

Adult flea beetles feed on the leaves and stems of potato plants causing lots of small holes in the foliage. The larvae, which hatch from eggs laid in the soil near potato plants, cause the most damage. They feed on roots, underground stems, and burrow into the tubers. Tuber feeding results in small brown tunnels in the tuber and a pimple like appearance on the tuber skin. This damage can result in the tuber becoming unsaleable.

Adult potato flea beetle and feeding damage.
Image courtesy of Gail Langellotto, https://www.flickr.com/photos/osumg/5833377827/in/album-72157626852660319/

Damage to a potato tuber caused by larvae of the potato flea beetle.
Image courtesy of Whitney Cranshaw, Colorado State University, Bugwood.org

Potato leafhopper *(Empoasca fabae)*

Description:

Potato leafhoppers are small, pale to bright green insects about 3 mm in size. They have long back legs which gives them the ability to hop and jump. Adults have a set of pale wings folded over their body while the nymphs are wingless. The adults also have 6-8 white dots at the base of their head and a white "H" type mark between their head and the base of their wings. Adult females lay 2-3 small, white eggs per day which hatch after approximately a week. When nymphs first hatch they are tiny, very pale, and gradually become darker green through their moulting cycles. It takes 5 moulting cycles for a nymph to become an adult.

Symptoms and damage

Both adults and nymphs damage plants through their feeding. Leafhoppers have piercing mouthparts which they inject into the plant to feed. This causes damage to the plant cells and results in damage called hopperburn. The first symptoms of hopperburn are curling at the edges of the leaves. The leaf edges may turn from yellow to brown and the leaves may eventually fall off. Hopperburn causes a reduction in photosynthesis and leads to a reduction in plant growth.

Note

Potato leafhoppers have a very wide host range and can feed and reproduce on over 200 different plant species.

Left: Nymphs of the potato leafhopper. Right: Adult of the potato leafhopper.
Note the distinctive white dots at the base of the head and the white markings between the head and the wings.
Nymph image courtesy of Scott Lewins, University of Vermont. Adult image courtesy of Mary Kreitinger, Cornell University https://blogs.cornell.edu/potatovirus/

Hopperburn caused by feeding of potato leafhopper adults and nymphs. Image courtesy of Ontario Ministry of Agriculture, Food and Rural Affairs (OMFRA), © Queen's printer for Ontario, 2018. Reproduced with permission.

Red spider mite *(Tetranychus evansi)*

Description

The red spider mite is one of a number of different spider mites that attack plants. Adults females are an orange red colour, have 8 legs, are oval, and approximately 0.5 mm long. They have two distinct dark patches on either side of their body. Adult males are smaller than females and are pale yellow to orange in colour. Eggs are small, round, and translucent orange to white in colour.

Symptoms and damage

Red spider mites feed on both sides of the leaf but prefer the underside of leaves. Their feeding causes white or yellow dots to appear on the leaf where the contents of the plant cells have been sucked out. If severe enough, this can cause the leaf to turn yellow and fall off, sometimes leading to the defoliation of whole plants. Red spider mites also produce a webbing which can cover plant parts. They can be spread in the wind, through irrigation water, or as a passenger on clothing, tools or host plants.

Note

Red spider mites have a wide host range. Unlike other spider mite species, they are not effectively managed with biological control, meaning that pesticide applications are often required to manage them.

Damage caused by red spider mite. Note this damage is on a bean leaf but symptoms are similar to that seen on potato. Image courtesy of Scot Nelson, https://www.flickr.com/photos/scotnelson/5684819124

Adult red spider mites. Note the male at the top and the female underneath.
Image courtesy of Alain Migeon, CBGP-INRA, France

Webbing caused by a severe infestation of red spider mites.
Image courtesy of Alain Migeon, CBGP-INRA, France

Andean potato weevil *(Premnotrypes sp.)*

Description

Adults are stoutly built, 8-10 mm in length, and are grey-brown, brown, or black. They hide on the soil surface during the day, emerging at night to chew round notches from the edges of leaves. Andean potato weevil larvae are white, 10-12 mm long, and burrow into the soil where they feed on potato tubers and produce irregular tunnels. Larvae are active for up to four months before pupating.

Notes

The Andean potato weevil is a significant pest in mountainous South America where adult infestations can strip entire crops of young potatoes. The larvae can damage up to 80% of tubers in a crop.

Feeding damage caused by the Andean potato weevil.
Image courtesy of International Potato Center Archives, www.forestryimages.org

Adult Andean potato weevils.
Image courtesy of K.V. Raman, Centro Internacional de la Papa, Peru.

Andean potato weevil larva.
Image courtesy of K.V. Raman, Centro Internacional de la Papa, Peru.

Colorado potato beetle *(Leptinotarsa decemlineata)*

Description

The adult Colorado beetle is 9-12 mm in length, with a yellowish-orange body and black stripes down its back. Eggs are bright yellow-orange, are shaped like a rugby ball, and are laid in masses on the underside of leaves. The larvae are yellow and black and can grow to 12 mm in length, eventually turning a reddish-pink with black spots down their sides. Over-wintering pupae are yellow in colour.

Symptoms:

Larvae emerge from the soil in spring and feed on newly sprouted potato plants, which they can rapidly defoliate.

Colorado potato beetle

Colorado beetle egg raft.
Image courtesy of John Fletcher, Plant & Food Research

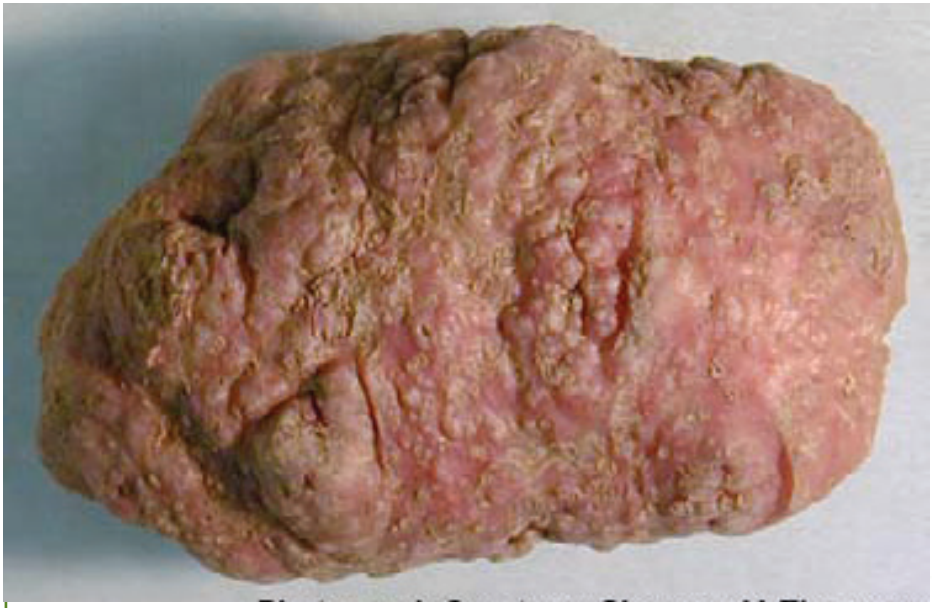
Colorado beetle larvae

Columbia root knot nematode

(Meloidogyne chitwoodi)

Symptoms

Above-ground symptoms of Columbia root knot nematodes are often not obvious but may consist of plant stunting, a lack of vigour, and a tendency to wilt under moisture stress, all leading to reduced yield. Like other *Meloidogyne* species, they may cause brown spotting inside potato tubers, but overall the symptoms caused by Columbia root knot nematode are often not easily detected. Potato roots may be infected, but this is difficult to detect without a magnifying lens, as little or no galling occurs, even in heavy infestations. When present on tubers, galls appear as small swellings on the surface above the developing nematodes.



Symptoms of Columbia root knot nematode infestation in a potato tuber – note that these symptoms may be difficult to distinguish from those of several other nematode species.
Image courtesy of Sherman V Thomson, Professor of Plant Pathology, Emeritus, Utah State University.

Symptoms of Columbia root knot nematode infestation in a potato tuber, with skin removed to show the internal spotting caused by female nematodes – note that these symptoms may be difficult to distinguish from those of several other nematode species. Image courtesy of Sherman V Thomson, Professor of Plant Pathology, Emeritus, Utah State University.

Dagger nematodes *(Xiphinema spp.)*

Symptoms

Dagger nematodes are found in the soil and attack roots and tubers. They are ectoparasites meaning they remain on the outside of the plant with just their mouthparts penetrating the plant roots. Dagger nematodes cause damage to plants through directly feeding on their roots. This feeding results in a gall developing at the root tip, reducing the efficiency of the plant root system. There are very few symptoms on above ground parts except for reduced growth as a result of poor root systems. Dagger nematodes are known to transmit some viruses through their feeding. The piercing mouthparts of these nematodes cause holes in plant roots which allow fungi and bacteria to invade the plant.

Transmission

Dagger nematodes have a long lifecycle and adults can survive in the soil for over a year. They can be spread through movement of infected soil on machinery, footwear, and other equipment. Dagger nematodes have a wide host range and can live on a number of weeds, ornamentals, and fruit and vegetable crops.

Needle nematodes *(Longidorus spp.)*

Symptoms

Needle nematodes are very similar to dagger nematodes as they are found in the soil and feed on potato roots and tubers. Like dagger nematodes, a gall can often be seen on the root tip where a needle nematode has been feeding. Needle nematodes are ectoparasites meaning they remain on the outside of the plant with just their mouthparts penetrating the plant roots. There are no direct above ground symptoms associated with needle nematodes except for a reduction in plant growth. They are also known to transmit certain plant viruses through feeding.

Transmission

Needle nematodes can be spread through movement of infected soil on machinery, footwear, and other equipment. Needle nematodes have a wide host range and can live on a number of weeds, ornamentals, and fruit and vegetable crops.

Root knot nematode *(Meloidogyne spp.)*

Symptoms

Potatoes infected with root knot nematodes can show varying degrees of yellowing, stunting and wilting. Infected plants have galls or knots on the root system. These galls are caused by the nematodes penetrating into the plant roots and feeding within the root tissue. Tubers may also be affected and show blisters or swellings on the outside of the tuber (eg. Columbia root knot nematode). Internal browning may also occur within the tuber between the skin and vascular ring. Root knot nematode infection reduces the size and quality of potato tubers and makes the plant more susceptible to other diseases.

Transmission

Root knot nematodes can survive in the soil as eggs and in tubers as adults and juveniles. They can be spread through infected tubers or through the movement of infected soil on machinery, footwear. and other equipment. Root knot nematodes prefer warm conditions and are more likely to thrive in areas with a warm climate.

Potato spindle tuber viroid *(PSTVd)*

Symptoms

Symptoms of potato spindle tuber viroid may not be visible until the second generation of infection, with severity increasing at higher growing temperatures. Plants may be stunted and quite upright in appearance. Stems may be more branched, forming sharp angles where they join the base, with small and stiff leaflets attached. Tubers are often elongated, may be cylindrical or conical (spindle-like) in shape, and growth cracks may be present. Tubers can also have rougher skin or more eyes than is usual and may be smaller than healthy tubers.

Notes

This viroid has been reported in New Zealand but only from glasshouse tomato and capsicum crops, and all detections have been eradicated.

Small, stiff leaflets caused by infection with potato spindle tuber viroid.
Image courtesy of Central Science Laboratory Harpenden Archives, British Crown, www.forestryimages.org

Distinctive tuber symptoms of potato spindle tuber viroid.
Image courtesy of Plant Protection Service Archives, Plant Protection Service, www.forestryimages.org

Distinctive tuber symptoms of potato spindle tuber viroid.
Image courtesy of Rudra P Singh, Ministry of Agriculture & Food, Canada.

Novel recombinant potato VY viruses

Symptoms

Potato virus Y and its various strains are one of the most important groups of viruses affecting potatoes. The different strains show varying degrees of symptoms, with some strains causing very mild symptoms and others causing major crop losses. Some strains of PVY are known to combine their genetic material to create new, novel virus strains. These are known as novel recombinant virus strains. Approximately 40-50 novel recombinant virus strains have already been identified within the potato virus Y group. Potato tuber necrotic virus (PVY^{NTN}) is one of the most important novel recombinant potato virus Y strains identified due to its ability to cause major tuber damage and crop losses.

Transmission

Most virus strains formed from PVY are transmitted through aphids such as green peach aphid and potato aphid. Viruses may also be spread through plant sap.

Potato tuber necrotic group *(PVY^{NTN})*

Symptoms

PVY^{NTN} is a strain of potato virus Y. It is known to induce potato tuber necrotic ringspot disease (PTNRD) which can make tubers unmarketable. Symptoms of PTNRD include a mild mosaic on leaves, stunting of shoots and leaves, and rough, dark rings on the skin of potato tubers. The tuber flesh may also be affected with browning occurring under the dark rings. Symptoms develop during tuber storage from reddish-brown rings on the surface which become raised, then developing into sunken craters.

Transmission

This virus is transmitted by several species of aphid such as green peach aphid and potato aphid. It may also be transmitted through plant sap. Plants grown from infected seed tubers also act as a source of infection for surrounding crops.

PVY^{NTN} © United Nations, 2014 UNECE (ECE/TRADE/416) 2014 ©FN3PT

PVY^{NTN} © United Nations, 2014 UNECE (ECE/TRADE/416) 2014 ©SASA

Potato mop-top virus *(PMTV)*

Symptoms

The most common symptom of PMTV is the development of yellow blotches in ring patterns on the middle and lower leaves. This may also be accompanied with a shortening of the internodes, giving a bunching or "mop-top" effect. Infected tubers may show no symptoms or may have raised, circular rings on the skin surface. Tubers may also develop brown lines and rings in the flesh from where the stolon was attached. These internal symptoms may not be present at harvest and can develop in storage.

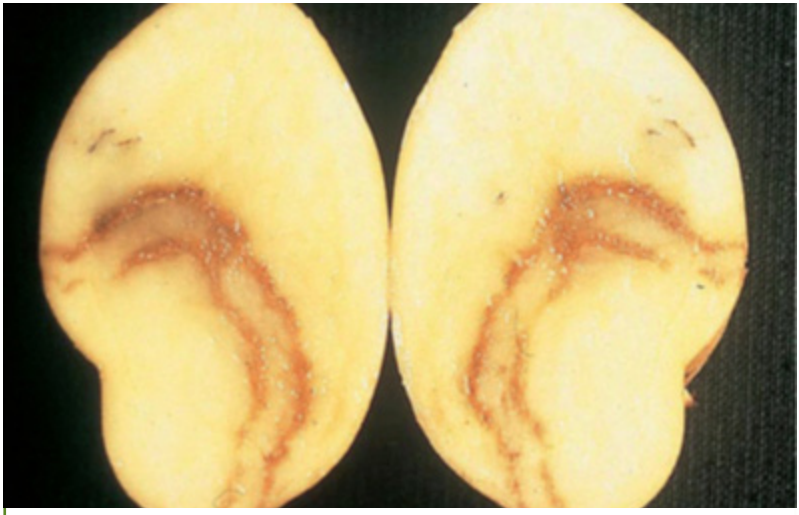
Transmission

PMTV is spread through the spores of *Spongospora subterranea* which cause powdery scab in potatoes. The spores act as a vector to transmit the virus into potato plants. These spores can survive for years in the soil making control difficult. PMTV may be spread through infected potato tubers but not all infected tubers result in disease development. Transmission through powdery scab spores is the main source of infection. PMTV is most prevalent in cool, moist soils.

Yellow splashes or chevrons on leaves caused by PMTV.

Bunching of leaves (mop-head) caused by PMTV.

Reddish-brown lines or rings on the tuber surface caused by PMTV.



Arcs of brown necrotic tissue through tubers caused by PMTV.

Glossary

Alate: some insects (such as aphids) can have either winged or wingless adult forms. The term “alate” is used to describe individuals that have wings.

Apex: the stolon end of a potato tuber is the end which is connected to the rest of the plant – the apex is the opposite end of the tuber, also known as the apical end.

Cornicle: the two tubes at the rear end of aphids which are separate from their tails, and through which aphids may secrete droplets of pheromones. Different species of aphid can sometimes be identified by the different shape and colouring of their cornicles.

Cortex: the layer under a potato tuber’s skin, but outside of the vascular ring.

Epidermis: the outer layer of the potato tuber’s skin, which is only a single layer thick. See also “periderm”.

Exoskeleton: a hard, outer layer that covers, supports, and protects the body of an invertebrate animal such as an insect or crustacean.

Eye: also known as lateral buds, potato eyes are the buds from which a new haulm can grow. Most eyes are near the apical end of the tuber. Some pathogens (including late blight and pink rot) can enter the potato through the eyes.

Frass: debris or excrement produced by insects.

Haulm: a potato stem.

Larvae: the active immature form of an insect, especially one that differs greatly from the adult and forms the stage between egg and pupa.

Lenticel: structures which allow gas exchange through a potato tuber’s skin. In very wet soils, lenticels may swell. Some diseases (including soft rots and late blight) can gain entry into the potato through the lenticel.

Lesion: a localised area of diseased tissue. A lesion can be any type of diseased tissue, such as a canker, blister, or scab.

Medulla: also known as the perimedullary tissue, this is the layer inside the vascular ring which is not the pith. This is the potato’s main storage area, with cells growing and multiplying at the tuber grows.

Necrosis: the death of a restricted area of tissue (e.g. part of a single leaf). Small diseased areas can be described as “necrotic”.

Nymphs: an immature form of an insect that does not change greatly as it grows.

Periderm: the thicker, corky layer beneath the epidermis of the potato tuber's skin. This layer contains any pigments which make the skin different colours.

Pith: also known as the inner medulla, this is part of the tuber's carbohydrate storage area. The pith is often star shaped, branching out from the centre towards each of the tuber's eyes.

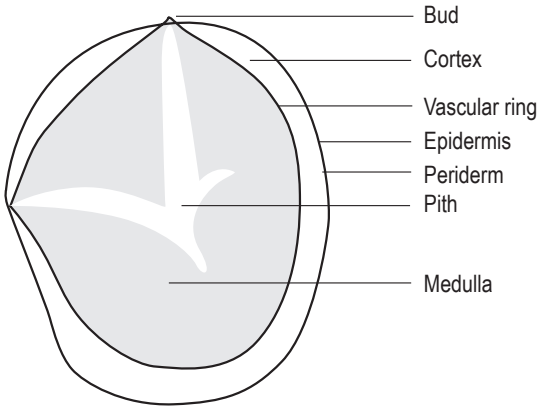
Rugose: wrinkled.

Sclerotia: a dense and hard fungal mass which contains stored food and can remain dormant for long periods.

Stolon: a horizontal stem growing just below the soil's surface.
The stolon or stem end of a potato tuber is the end which connects to the rest of the plant.

Thorax: the middle section of the body of an insect, between the head and the abdomen, bearing the legs and wings.

Vascular ring: the cells in a potato tuber which carry carbohydrates into the medulla from the stem and leaves. The vascular ring is often visible when a tuber is cut in half.



Vector: an organism that transmits a disease or parasite from one animal or plant to another.

Notes


Potatoes
NEW ZEALAND