WASHINGTON POTATOES

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Insects, Nematodes & Pathogens

Important to Potatoes in the Pacific Northwest

Provided by the Washington State Potato Commission

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FORWARD

The Washington State Potato Commission supports Integrated Pest Management. The key to managing Pacific Northwest potato pests lies in identifying them, understanding the damage they cause and monitoring until treatment is warranted.

This guide includes photos and diagrams of various pests and pathogens, the damage they cause, details of their life cycles and pest management tips.

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WASHINGTON POTATOES

Table of Contents

Table of Contents (continued)

Pests: Colorado Potato Beetle

Colorado potato beetles mating.

The adult Colorado potato beetle, Leptinotarsa decemlineata (CPB), is a yellow and black striped beetle, about 0.5 inch long and 0.25 inch wide. Larvae are reddish orange, with two rows of black spots on each side. They lay yellow egg clusters, usually on the underside of leaves.

Colorado Potato Beetle eggs on he underside of a potato leaf.

CPB biology and damage

1. Both larvae and adults feed on potato foliage through the season; high population densities can cause serious defoliation. Pupation occurs in the soil. Adults overwinter in the soil, emerging to feed, lay eggs, and mate in the spring.
2. In cool climates, the beetle undergoes only one generation per season, but in warmer areas, such as the southern Columbia Basin, it may have up to three generations.
3. Other host plants of CPB include solanaceous weeds such as nightshade, and crops such as tomato and eggplant. They have been observed in large numbers feeding on hemp.
4. Check fields for CPB starting at crop emergence. CPB infestations tend to start at the border of the field, particularly next to fields with volunteer potatoes. Beetles are easily spotted when plants are small, because larvae feed toward the tops of the plants.
5. The CPB has developed high levels of resistance to insecticides in many parts of the country. Populations in the PNW are still susceptible to most labeled products.

Colorado potato beetle larvae and feeding damage on potato.

Colorado potato beetle larvae.

Aphids on Potato

Green peach aphid -- *Myzus persicae*

Green Peach Aphid (GPA) Biology & Management

1. GPA is by far the most important aphid species in Washington potatoes.
2. GPA is a very effective vector of potato viruses like PVY and leaf-roll virus.
3. GPA usually becomes abundant in potato fields in July.
4. GPA overwinters as eggs on peach trees or as nymphs and adults on weeds.
5. Many insecticides are available that control GPA, but be aware that pyrethroid insecticides kill aphid predators and parasites, allowing aphids to flare.

Potato Aphid -- *Macrosiphum euphorbiae*

**Most commonly found in potatoes very early in season.
**Effective virus vector.
**Much larger than green peach aphid.

Washington State Potato Commission

Potato aphid is often found on actively growing shoots.

Like many aphids, potato aphid can be green or pink.

Overwinters on weeds or as eggs on rose bushes.

Aphids


Green Peach Aphid

Morphs of aphids--
**Each aphid species has both winged and wingless adult "morphs."

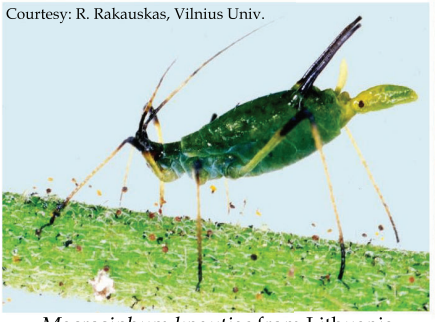
**The winged and wingless morphs often look very different, as in these green peach aphids.

**Aphids develop into winged adults in response to crowding and/or changes in host plant quality.


Green Peach Aphid

Aphids give birth to live young, rather than laying eggs. This is one reason their numbers can grow so fast. The other main reason is that baby aphids are born pregnant!

All aphids in potato fields are females. Aphids reproduce parthenogenetically, which means that each aphid is genetically identical to its mother -- much like clones are genetically identical.


Courtesy: R. Rakauskas, Vilnius Univ.

Macrosiphum knautiae from Lithuania


Baby green peach aphid

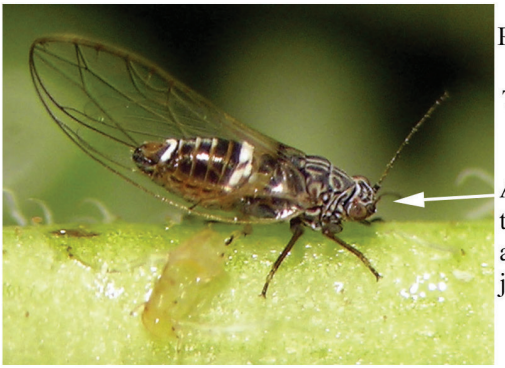
Many aphids prefer plant tissue that is starting to yellow -- more nutrients are moving in the sap that the aphids eat.


Aphid mummy

Aphids are often parasitized by wasps whose larvae eat the aphid from the inside out. These dead aphids are called mummies.


Parasitoid wasp larva

Psyllids



Psyllids are close relatives of aphids and whiteflies, and are also known as "jumping plant lice." These pictures are all of the **potato psyllid**. This is the only psyllid found in potatoes in the U.S.

Adult potato psyllid - white stripes on the head and thorax, and bold white bands on the abdomen are distinctive for potato psyllid. They are able to jump long distances very quickly when disturbed.

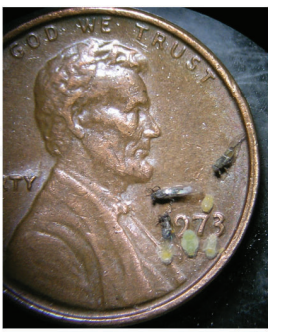
Psyllid egg on leaf edge. Each egg is on a short stalk.

Young psyllid nymph.

Older psyllid nymphs, showing their strange tubes of excrement.

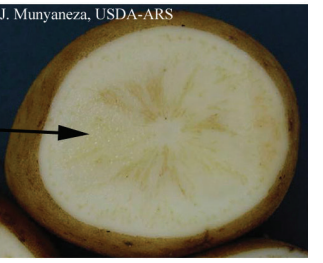
Psyllid nymph side view - psyllid nymphs have functional legs and are capable of walking, unlike whitefly nymphs (see reverse).

Psyllid nymphs and adults on a penny for size reference.



Psyllid biology and damage

1. Potato psyllids are thought not to overwinter in Washington, but arrive here from southern locales by mid-summer. Many fields will have some psyllids present by mid-July.
2. Potato psyllid transmits the bacteria that causes "zebra chip." Zebra chip symptoms had not been seen in the Northwest until 2011 when the disease was widespread in OR, WA, and ID.
3. Psyllids can rapidly develop resistance to insecticides. Great care must be taken to alternate modes of action in psyllid control.

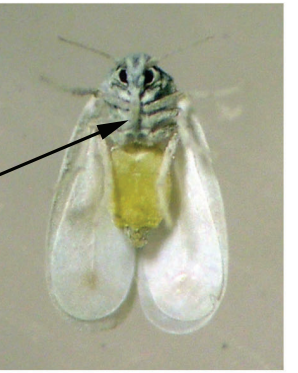


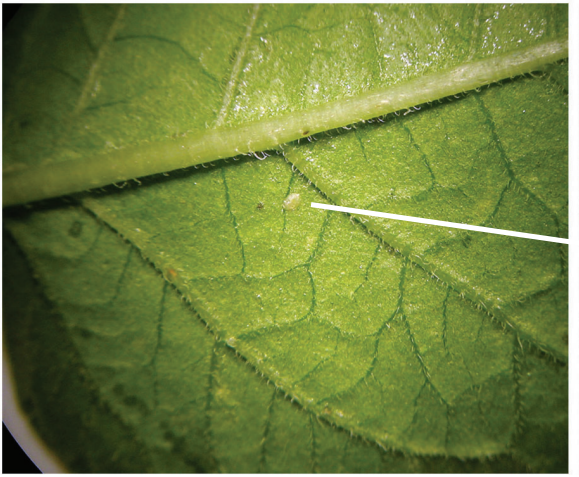
Whiteflies

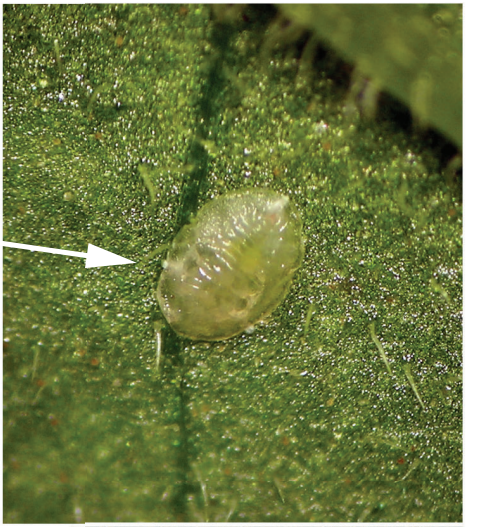
Adult whiteflies are less than 1/8" long and resemble tiny moths.

Whiteflies are close relatives of aphids & psyllids, feeding on plant sap through piercing-sucking mouthparts.

Immature whiteflies resemble immature psyllids (see reverse) and are sedentary throughout development.







These two pictures are of the same whitefly nymph, and show the size of a full-grown nymph compared to a potato leaf.

The adult whitefly's eyes can be seen before it emerges from the nymphal skin.

Whitefly biology and damage

1. Whiteflies are present in many potato fields, but rarely if ever require control in the Pacific Northwest.
2. The whitefly most common in Washington potatoes is the greenhouse whitefly, not the silverleaf whitefly that is so feared in the southern U.S.
3. Whiteflies are most diverse and abundant in warm-temperate and tropical environments.

Purple Top and Beet Leafhopper

Foliar Symptoms

Leaves of infected plants turn purple and curl. Infected plants may die early.

Nodes swell and turn purplish, and axial buds elongate.

Aerial tubers may form on the stems.

Causal Agent

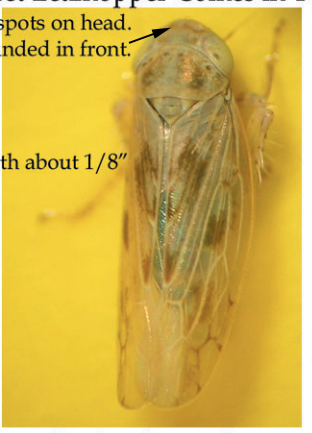
Name: Columbia Basin Purple Top Phytoplasma (a.k.a. BLTVA)
Transmitted by: Beet leafhopper (see reverse of this card)
Hosts: Beet leafhopper, various weeds, potatoes, tomatoes, various vegetables
Other info: Disease is transmitted mostly in early season.

Purple Top and Beet Leafhopper

Leafhopper Identification on Yellow Sticky Traps

Beet Leafhopper Comes in Two Color Forms

Light-colored form of beet leafhopper



Darker form of beet leafhopper

Sometimes beet leafhoppers on sticky traps may be damaged or missing wings.

Beet leafhopper = *Circulifer tenellus*

Other Leafhoppers, Which Do Not Transmit Purple Top

Empoasca

Exitianus

Dikraneura

Latalus

Trapping suggestions:

1. Use 3X5" or 4X6" yellow sticky card traps.
2. Place traps near potato fields, among weeds, away from dusty roads.
3. Mount cards about 3-4" above ground.
4. Check traps regularly, replace at least weekly.
5. May and June are the most important months.

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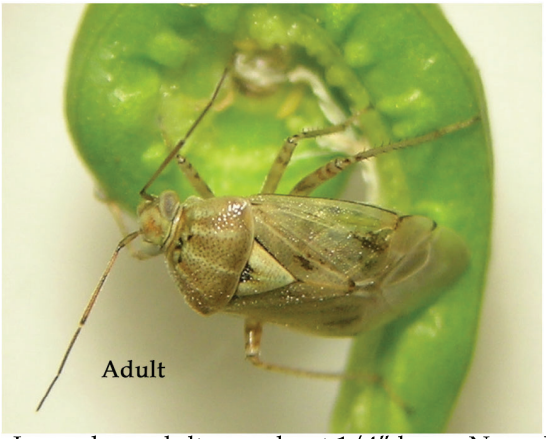
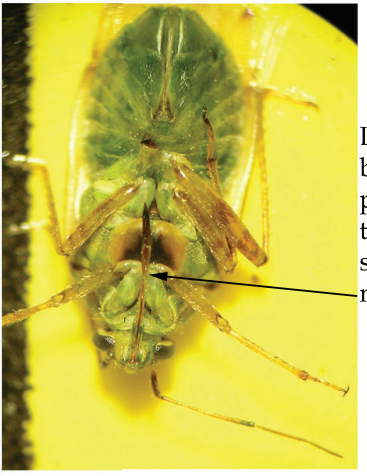
True Bugs: Lygus Bugs



Lygus bug adults are about 1/4" long. Nymphs and adults are both usually green, but can be shades of orange or red.

Lygus are active, often seen on leaves and flowers in potato fields.



Lygus feed by sucking plant sap through specialized mouthparts.

Lygus bug biology and damage

1. Lygus bugs can feed on many different plants. They can be found in potato fields throughout the season.
2. Damage associated with lygus includes flagging of leaflets. Potato fields often support large numbers of lygus without visible damage.
3. Lygus infestations in potatoes seem to rarely require insecticide treatment.
4. Lygus can appear suddenly when they move from neighboring crops such as freshly cut hay or seed crops.

True Bugs: Stink Bugs

Stink bugs in potatoes, belonging to the genus *Chlorochroa*.

Egg mass

Hatching eggs.

Partly grown nymph.

Stink bugs are often easy to see on the leaves and stems of potatoes.

Stink bugs like these, in the genus *Perillus*, are **predators** of Colorado potato beetle eggs and larvae.

Nymphs

Adult

Stink bug biology and damage

1. Stink bugs looking much like *Chlorochroa* pictured above feed on many different plants. They can be found in potato fields throughout the season, but most often move into potatoes from neighboring crops, weeds, and native plant communities.
2. Damage associated with stink bugs includes flagging of leaflets, whole leaves, and growing tips.
3. Stink bugs often seem to be clumped within fields. Treatment of entire fields for control of stink bugs is normally not required.

Potato Tuberworm

Foliar Damage

Larvae live in the leaves and stems during the growing season

Tuber Damage

Tubers exposed at surface are most likely infested

This tuber had 5 large larvae

Tuberworm life stages

Eggs

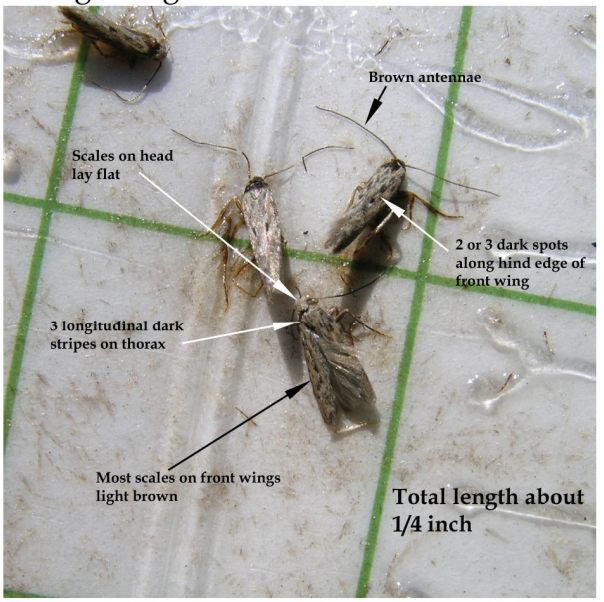
Mature larva ~1/2 inch long

Larva in tunnel

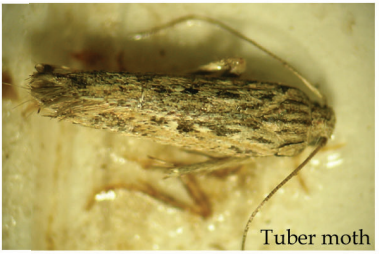
Cocoon on potato

Potato Tuberworm

Recognizing Adults

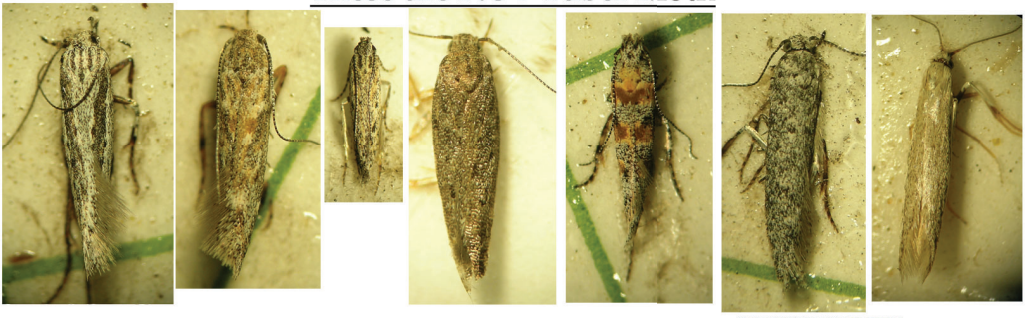


Markings and color can vary



Many other small moths like these are found in tuber moth traps placed near native shrubs and herbs

These are NOT Tuber Moth



Trapping suggestions:

1. Use Delta style traps
2. Replace lures every 6 weeks
3. Store lures in freezer until use
4. Replace sticky cards weekly to maintain stickiness
5. Place traps in or near potato fields, about 12″ above ground
6. Handle the lures with tweezers

Caterpillars (a.k.a. "Worms"): Loopers


Photo: Dax Dugaw

Larva and adult of cabbage looper (*Trichoplusia ni*). This is the only looper species of concern in Washington potatoes. Entomologists spread and dry moths in this position to aid identification. In life the moth rests like the cutworms & armyworms on the other side of this card.

Loopers are close relatives of cutworms and armyworms (see reverse), but are easily recognized by having only 3 pairs of posterior prolegs, & they walk in an inch-worm fashion.

The pupal stage of loopers, cutworms, and armyworms look alike.


Photo: Dax Dugaw

Other loopers are sometimes found in potato fields, but research shows that that they cannot develop well on potatoes and are not pests.

Celery looper (*Autographa falcifera*).

Looper pest status and biology

1. There are many species of loopers, but recent research shows that only cabbage looper is a pest of potatoes in Washington.
2. Cabbage looper larvae develop very quickly on potatoes -- in as few as 8 days. This means there can be several generations per year.
3. Scouting for loopers is important. Be sure loopers are still present before treating -- oftentimes damage is not noticed until larvae are fully developed.
4. Like other caterpillars, large larvae are the most difficult to control with insecticides.

Caterpillars (a.k.a. "Worms"): Armyworms & Cutworms


Photo: Dax Dugaw


Photo: Dick Wilson

Larva and adult of bertha armyworm (*Mamestra configurata*).


Photo: Dax Dugaw

Larvae and adult of western yellow-striped armyworm (*Spodoptera praefica*). Armyworms and cutworms often curl up when disturbed.


Photo: John Davis


Photo: Dax Dugaw


Photo: John Davis

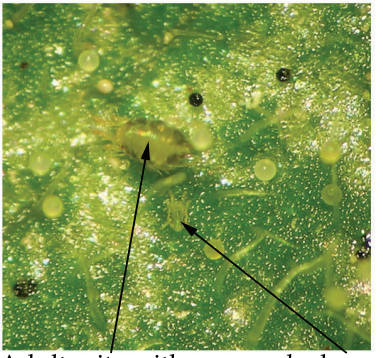
Spotted cutworm (*Xestra c-nigrum)* larva and adult.

Armyworm and cutworm pest status and biology

1. Recent research has shown spotted cutworm, bertha armyworm and cabbage looper (see reverse) to be the most important caterpillar defoliators in WA potatoes.
2. The pupal stage of some moths occurs in the soil (see reverse for a photo).
3. These caterpillars can be difficult to find since they are often most active at night. Look in the soil or under debris in the field.
4. Many species of moths lay eggs on potato plants -- sometimes singly and sometimes in large batches.

Leaf-Stippling Pests: Spider Mites

Two-spotted spider mite adult w/ eggs



Adult mite with eggs and a larva

Spider mite damage of varying degrees on a single leaf. Note the webbing and the mites scattered on the webs.

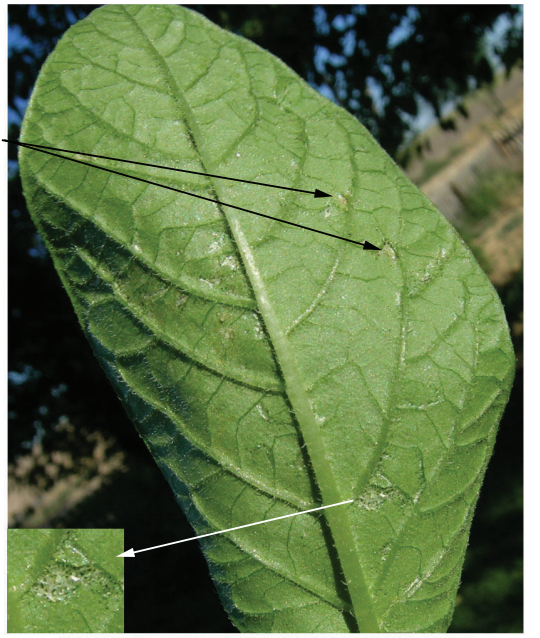
General Information

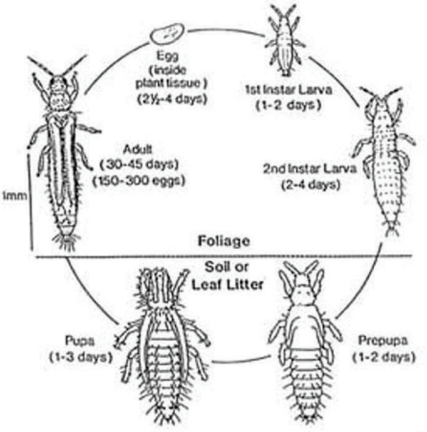
1. Most common species on potato:
   Tetranychus urticae, two-spotted spider mite.
2. Two-spotted spider mite is common on weeds and crops.
3. Several things can contribute to spider mite outbreaks: a) non-selective pesticides, such as pyrethroids;
   b) proximity to certain crops such as corn, alfalfa, hops, and mint, which tend to harbor mites; c) proximity to dusty roads; d) hot, dry weather.
4. Scouting for mites should begin in late June or early July. A hand lens is required for field recognition.
5. If a miticide is used, it must be applied early in the infestation.

Leaf-Stippling Pests: Thrips

Western flower thrips

Pockets of thrips damage





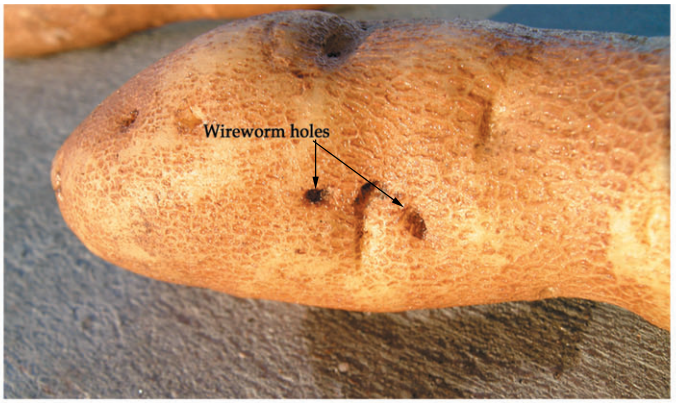
Thrips general life cycle

Thrips are very small.

General Information

1. Most common species on potato:
   Frankliniella occidentalis, western flower thrips.
2. Western flower thrips has a very large host range, and occurs almost everywhere potatoes are grown in Washington.
3. Thrips feed by draining cells near the surface of the leaf.
4. Potatoes can be colonized early in the season.
5. The factors that lead to thrips outbreaks in potatoes are not well-understood.
6. Large populations can build in nearby crops such as corn, then colonize potatoes.

Wireworms



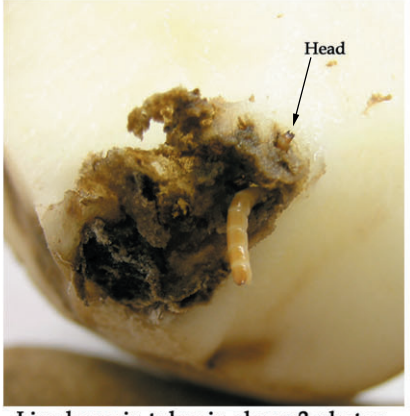
Typical damage.
Wireworm damage at harvest is often in the form of clean, straight, healed tunnels going only a fraction of an inch into the tuber. Larvae are rarely found in this kind of damage.

Unusual damage -- infested at harvest.
Tubers are sometimes infested late in the season or after vine kill, and then larvae are usually still present, and tunneling can be extensive, unhealed, and filled with decomposing organisms.

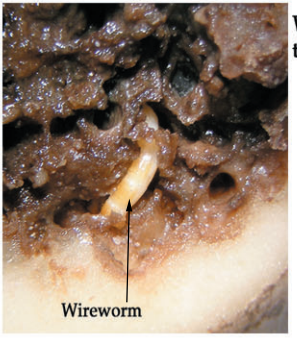

External symptoms.

Internal damage partly exposed.


Internal damage fully exposed.

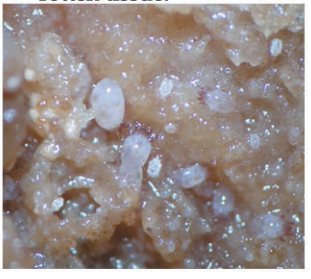


Live larva in tuber in above 3 photos.



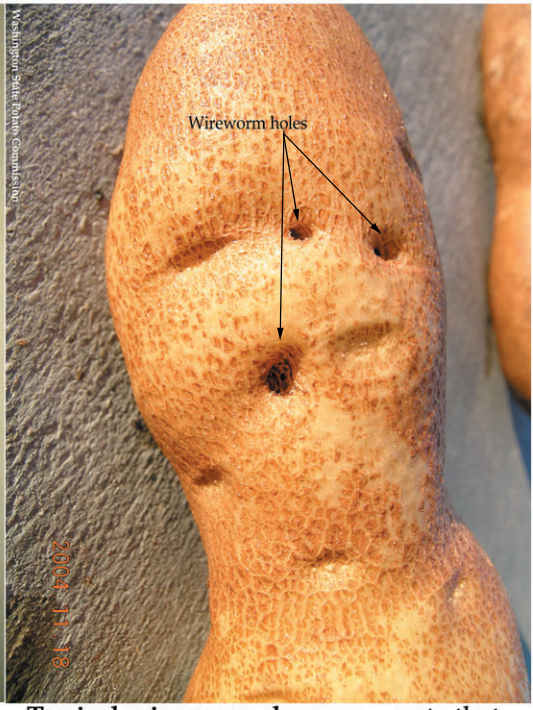
Wireworms initiated this rot.

Decomposer mites move into active tunnels and rotten tissue.



Wireworms

Large wireworm larvae. These were taken from harvested tubers (see reverse). Wireworms are not normally found in damage like that at the right.



Typical wireworm damage -- note that wounds are healed. This kind of wireworm hole usually penetrates the tuber for only a short distance.

Adult *Limonius canus*.
Most wireworms affecting potatoes in eastern Washington are *Limonius* spp. Western WA faces new European wireworms, *Agriotes* spp.
Adults are also known as 'click beetles'.

Biology & Management

1. Very long life cycle, with individual larvae often living 2-3 years in the soil.
2. Adults emerge and fly in the spring.
3. Potato crops following grain crops or weedy fallow are especially at risk.
4. Sampling for larvae is possible, but an effective method to predict damage risk has not been developed.
5. Damage can occur in spring to seed pieces, to tubers during bulking, and after vine kill (avoid in-field storage to prevent the latter type of damage).
6. The fumigant Telone can effectively control wireworms, but should be applied in the fall before soil temperatures cool and wireworms move deeper.

Predators: Ground Beetles

Common Ground Beetles in Potatoes

Bembidion species. This one is about 3/4 as large as the one to the right.

Bembidion species usually have golden markings.

Harpalus species -- these beetles often have orange-ish legs. They are slightly bigger than *Amara*, pictured below.

Bembidion species on penny for size reference.

Amara species on penny for size reference.

Amara species. These beetles are sometimes very shiny or appear metallic.

Predators: Ground Beetles

Ground Beetle Biology

1. "Ground beetle" is the common name used for members of the family Carabidae.
2. As the name implies, ground beetles spend most of their time on the ground. They feed primarily on other insects.
3. In potatoes, ground beetles can be very common under the canopy. They feed on insects that fall from the canopy or that are living in the decomposing leaves.
4. *Bembidion* beetles (below and reverse) are commonly seen scurrying along open patches of soil during the day. They can be very abundant.
5. Other species in the genera *Harpalus* and *Amara* (reverse) can also be common, especially in organic fields or conventional fields with a soft insecticide program.
6. Larvae of ground beetles live in the soil and are predators of soil dwelling arthropods. They likely feed on larvae and pupae of pest insects such as "worms" (moth larvae) and tuberworm.

Bembidion beetle between potato rows.

Similar Beetles

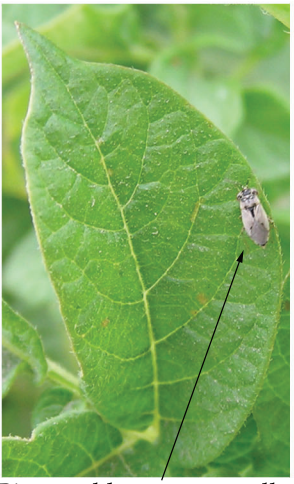
Darkling beetles (left) walk about on the ground and are often confused with ground beetles. They are mostly scavengers as adults.

Rove beetles (above) can also be common under the potato canopy. <u>These are also predators.</u>

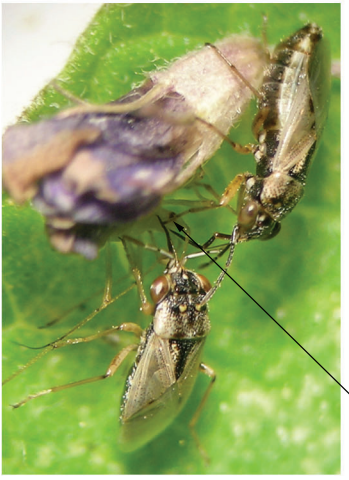
Predators: Big-Eyed Bugs

There are two major types of big-eyed bugs in potatoes. The lighter type on the left is far more common than the black one.

Young big-eyed bugs look a lot like adults, but don't have wings.



Big-eyed bugs are small, a little bigger than aphids.



These big-eyed bugs shared an aphid, sucking out the fluids.

Big-eyed bugs sometimes feed on plants when prey is scarce. This allows them to stay in a field until more prey is present.

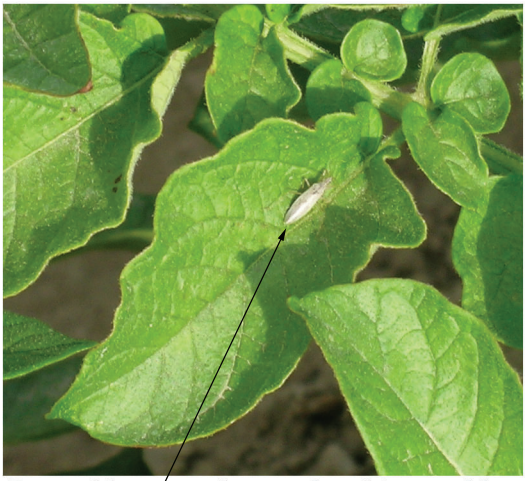
Big-eyed bug biology

1. Big-eyed bugs are present throughout the Columbia Basin, and are common in or near most potato fields.
2. Adult big-eyed bugs are present in early spring and colonize potato fields early.
3. They are sensitive to many insecticides -- care must be taken to preserve them.
4. Big-eyed bugs are generalist predators, feeding on almost any insect small enough for them to catch, but they are a major predator of aphids in potatoes.

Predators: Damsel Bugs

Adult damsel bug feeding on an adult *Lygus* bug.

Damsel bugs are generalist predators, feeding on many of the pest insects in potatoes. They use their strong front legs to capture prey.



The aphid's body fluids are sucked through the "beak."

Immature damsel bug feeding on an aphid.

Damsel bugs are larger than big-eyed bugs. Both are very active and hard to spot among the leaves.

Damsel bug biology

1. Damsel bugs are common nearly everywhere potatoes are grown in Washington.
2. Adult damsel bugs colonize potato fields in later spring, and nymphs can be found during the summer months.
3. In addition to aphids and *Lygus*, damsel bugs will feed on caterpillars like loopers and armyworms, and the eggs and young larvae of Colorado potato beetle.
4. Like all beneficial insects in potatoes, damsel bugs are very sensitive to broad-spectrum insecticides like pyrethroids, organophosphates, and carbamates.

Predators: Flower Flies (a.k.a. Syrphids)

Adults are not predators, but are mainly nectar feeders.

Flower flies often resemble bees or wasps.

Flower flies lay their eggs amongst their aphid prey.

Larvae are blind, free-living maggots that patrol for aphids by tapping their heads from side to side as they crawl on foliage.

Flower fly biology

1. Many flower flies are generalist predators, specializing on aphids and other soft-bodied insects. Some flower flies, however, are not predators, feeding instead on decaying organic matter.
2. A large larva can wipe out dozens of aphids per day.
3. Flower flies are common in most habitats, but their larvae will usually be abundant only where prey densities are high.

Predators: Lacewings

Photo: Stephen Luk

Snakeflies are close relatives of lacewings, and also predators.

There are two broad categories of lacewings commonly found in crops, the brown lacewings and green lacewings.

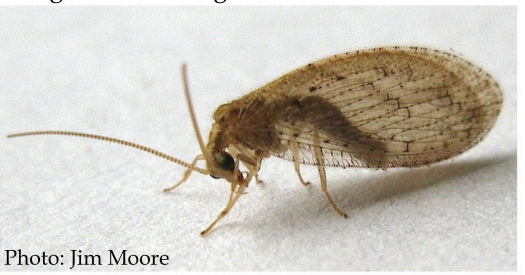


Photo: Jim Moore

Photo: Thom Schaefer

Photo: Marshall Dyer

Green lacewing larva (left) and the stalked egg (right).

Photo: John Maxwell

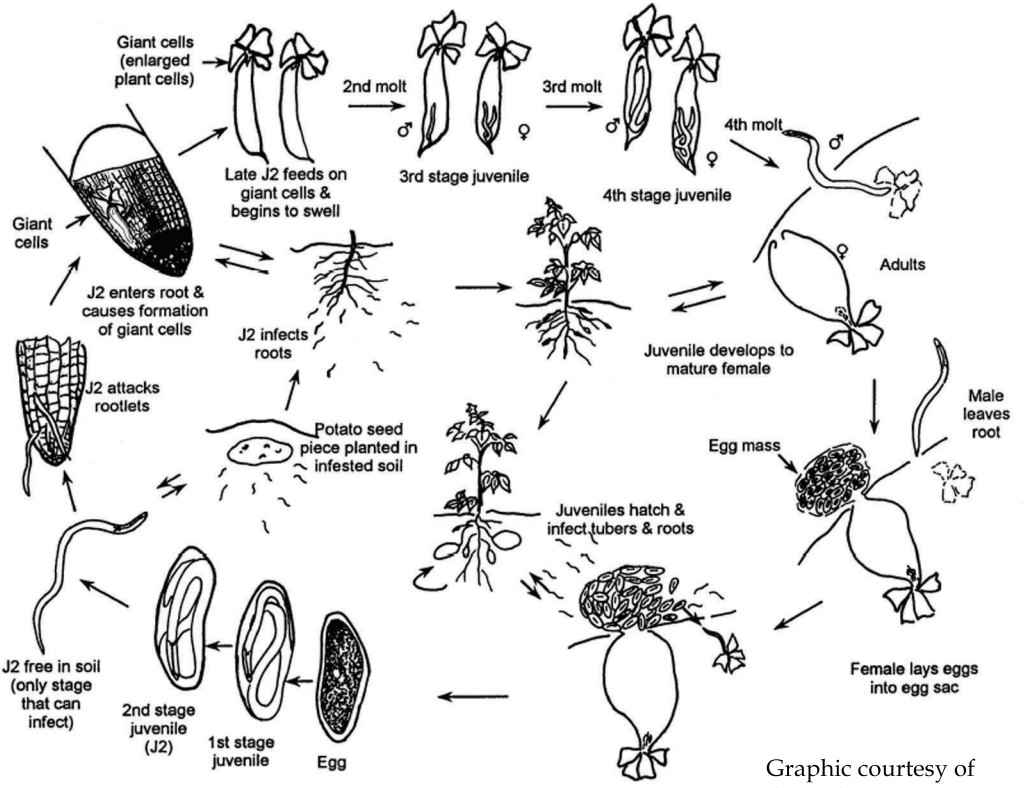
Brown lacewing larva.

Lacewing biology

1. Lacewings (and snakeflies) are generalist predators in many crops, gardens, and natural settings. The larvae feed on softbodied prey by sucking body fluids through the long curved jaws. Adults chew up their small insect prey.
2. Lacewings occur throughout potato producing areas, but are only sometimes abundant in crops.
3. Like other predators, they are sensitive to many insecticides -- care must be taken to preserve them.

Root-Knot Nematodes

Root-knot nematodes have a complex life cycle.



Graphic courtesy of Gerry Santo.

General Information

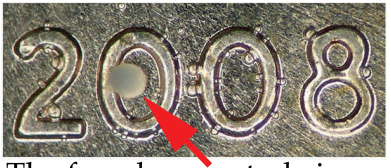
Nematode species: *Meloidogyne chitwoodi* (Columbia root-knot nematode), *Meloidogyne hapla* (northern root-knot nematode)

Biology: These plant-parasitic nematodes have complex life cycles (see above) involving a mobile stage that invades plant roots and tubers, and sedentary stages embedded in plant tissue. Root-knot nematodes overwinter easily throughout the Northwest. Most live in the top two feet of soil, but sometimes they are found up to 6 feet deep.

Distribution: Both northern- and Columbia root-knot nematode are widely distributed across the western states of the U.S. In the Northwest, Columbia root-knot nematode is most prevalent and damaging.

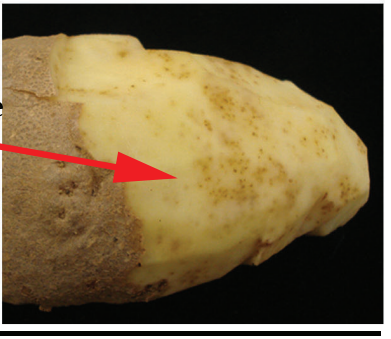
Root-Knot Nematodes

Tuber symptoms of Columbia root-knot nematode. Severe external symptoms on the left (large galls), compared with more typical symptoms on the right (much smaller galls).



The female nematode is actually pear-shaped and fits inside the 0 on a penny.

Female nematodes in tuber flesh cause discolored spots.



Management Information

1. Synthetic nematicides and soil fumigants are important and often necessary tools for nematode management in potatoes due to very low market tolerance for damage.
2. Crop rotation strongly affects nematode population size in the field. Each nematode species has a different host range. Therefore, sample and identify nematodes from each field and design crop rotations that will limit population growth.
3. Various green manure and cover crops can reduce nematode populations.
4. Prevention is also important: plant only certified seed tubers, and avoid moving soil from infested to uninfested fields.
5. Weed management between potato crops is also critical. Some weeds are good hosts for root-knot nematodes.

Root-Lesion Nematodes

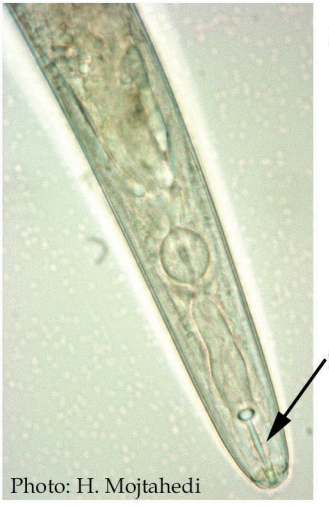


Photo: H. Mojtahedi

Pratylenchus penetrans, head end of female (left) and male (right), tail end of male (below).

Stylets used to penetrate plant cell walls and feed on their contents.

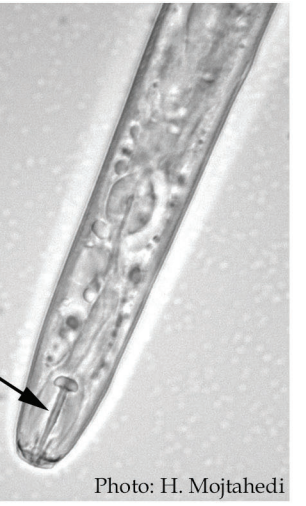


Photo: H. Mojtahedi

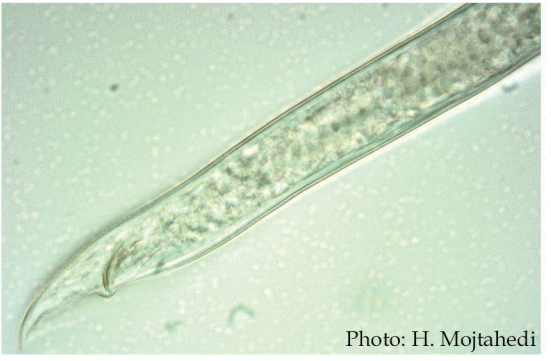


Photo: H. Mojtahedi

Total length of an adult *Pratylenchus* is about 0.5 mm. Careful examination by specially-trained technicians is required to accurately identify these and other nematodes in soil samples. For example, certain features of the tail end (left) are used to recognize many nematodes.

Management Information

1. Synthetic nematicides and soil fumigants are important and often necessary tools for root-lesion nematode management in potatoes.
2. Many crops are suitable hosts for root-lesion nematodes, but nonetheless careful choice of crop, and even cover crop, immediately preceding potatoes can reduce damage potential (e.g., mustard cover crops can reduce *Pratylenchus* numbers in soil).
3. Regular soil testing is a critical aspect of root-lesion nematode management, and spot treatment assisted by grid sampling and GPS technology is a viable management approach.

Root-Lesion Nematodes

Root-lesion nematode life cycle

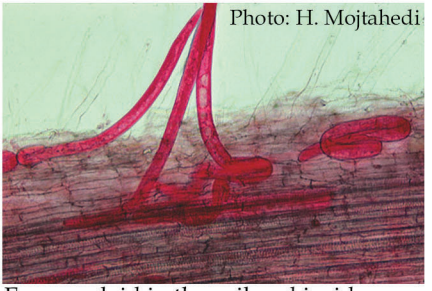
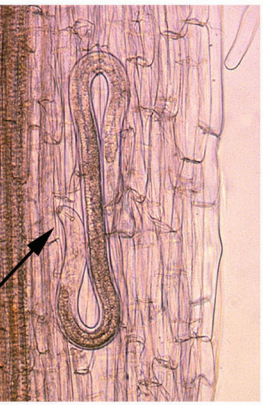


Photo: H. Mojtahedi

Eggs are laid in the soil and inside plant roots. Juveniles hatch and colonize roots. Some individuals move from root to root during their development.

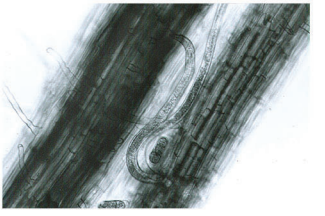
Nematodes take up residence in the root cortex.

Head end and stylet



Photos: H. Mojtahedi

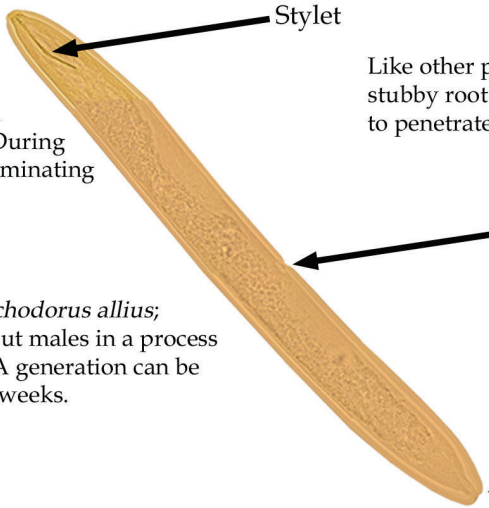
Root symptoms are lesions that turn dark and extend beyond the nematode's feeding site of the nematode. *Pratylenchus* infection sites are often invaded by soil microorganisms, resulting in more severe lesions.



General Information

Nematode species: *Pratylenchus neglectus* and *Pratylenchus penetrans*, primarily.
Biology: All stages of root-lesion nematodes are worm-like and capable of parasitizing roots. They feed either externally or establish themselves in the root cortex.
Root-lesion nematodes have very wide host ranges, including both broad-leaf plants and grasses. A complete life cycle takes 1-2 months, depending on soil moisture and temperature. Severe infestations cause foliar symptoms such as yellowing and stunting. There is a well-documented link between root-lesion nematodes, especially *P. penetrans*, and severity of early dying in potatoes.
Distribution: Historically *P. neglectus* has been predominant in the Northwest, but recently *P. penetrans* has been more commonly found.

Stubby-Root Nematodes



As nematodes grow they shed their outer "skin," a process called molting. During each molt any TRV contaminating the stylet is lost.

Like other plant parasitic nematodes, stubby root nematodes use their stylet to penetrate plant cells.

Males are rare in *Paratrichodorus allius*; females reproduce without males in a process called parthenogenesis. A generation can be completed in less than 3 weeks.

The importance of stubby-root nematode in potato is entirely related to its ability to transmit *Tobacco rattle virus* (see reverse).

Photo: H. Mojtahedi

General Information

Nematode species: Various species of *Trichodorus* and *Paratrichodorus* are included as stubby root nematodes. The most important species in the Northwest is *Paratrichodorus allius*.

Biology: Stubby-root nematodes are ectoparasites (living outside the plant roots) that feed on the tips of roots and can cause root stunting. These nematodes reach higher populations in coarse, sandy soils that are kept moist. Damage can be caused by very low nematode populations when they are infective; as few as 3 *P. allius* per 250 cc of soil can cause serious losses. If a field has previously suffered from TRV, it is likely still at risk even if no stubby root nematodes are found.

Distribution: Stubby-root nematodes are wide-spread in potato production areas of the Northwest.

Tobacco rattle virus/Corky Ringspot

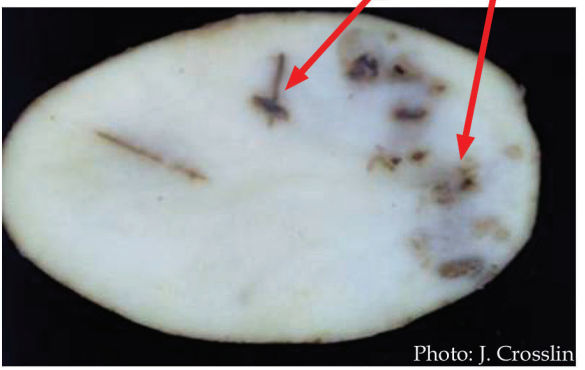
TRV infection can cause external tuber symptoms like these arcs and rings.

Internal tuber symptoms are varied, but include necrotic arcs, stripes, and blotches.

Tuber symptoms like these caused by TRV are referred to as corky ringspot disease in North America, and called spraing in Europe. Other viruses can cause similar symptoms -- e.g. *Potato virus Y* and *Potato mop-top virus*.

Tuber symptoms result from infectious nematodes feeding directly on the tuber.

TRV can infect a wide range of hosts, and in some weeds can be carried in the seed. Dispersal from field to field in infected weed seed is therefore possible.



Management

1. **Certified seed:** because TRV can move in potato seed tubers, it is critical to buy certified seed from farms or areas without TRV.
2. **Crop rotations:** some crops are hosts of TRV and *P. allius*, while others are only host to the nematode but not TRV. The latter type of crop is preferred because the virus will be eliminated in the nematode population as it feeds on plants that do not host TRV. Rotation crops that reduce TRV in subsequent potato crops include certain alfalfa, barley, and spearmint cultivars.
3. **Weed management:** several common weeds are excellent hosts for TRV and should be controlled; the most important are nightshades.
4. **Chemical control:** soil fumigation and certain in-furrow nematicides can effectively reduce corky ringspot in infected fields.

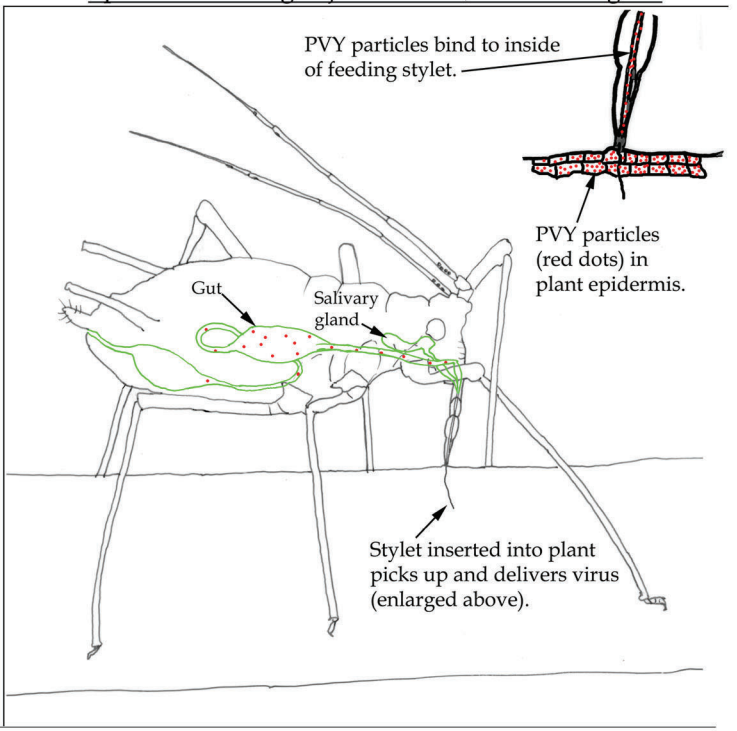
Potato Virus Y (PVY)

Green peach aphid
Myzus persicae

Rose-grass aphid
Metopolophium dirhodum

Sunflower aphid
Aphis helianthi

Aphids transmit PVY-- lots of different kinds of aphids including but not limited to:
Green peach aphid -- on many crops and weeds
Potato aphid -- on many crops and weeds
Bird cherry-oat aphid -- on wheat, corn, grasses
English grain aphid -- on wheat, grasses
Rose-grass aphid -- on wheat, grasses
Pea aphid -- on alfalfa, peas, other legumes
Sunflower aphid -- on some crops and many weeds
Melon aphid -- on many crops and weeds
Winged aphids are most important PVY vectors, picking up or transmitting in just seconds, then moving on.



Management

1. Many species of aphids transmit PVY in the first seconds of tasting a plant. No insecticide can act quickly enough to stop transmission.
2. For commercial growers, the best PVY management is to buy clean seed, and to control alternate hosts of PVY in and around fields such as volunteer potatoes and nightshades.
3. Also important is avoiding massive aphid flights from nearby potato fields, and even from other crops that harbor PVY vectors, such as alfalfa, wheat, and corn.

Potato Virus Y

Mild mosaic in foliage of cultivar Shepody.

Vein burning on underside of leaf.

There are numerous strains of PVY that cause many symptoms including yield loss.

Internal ringlets in cultivar Alturas caused by a tuber necrotic strain of PVY.

Severe skin lesions caused by another strain of PVY.

Severe reaction of cultivar Ranger Russet to the common strain of PVY.

Potato Leafroll Virus (PLRV)

Foliar symptoms include:
1. Curled leaves,
2. Yellowed foliage,
3. Sometimes reddish or purplish leaves,
4. Affected foliage often has a stiffer texture, referred to as "leathery."

Symptoms of PLRV in the field can easily be confused with purple top or rhizoctonia stem canker.

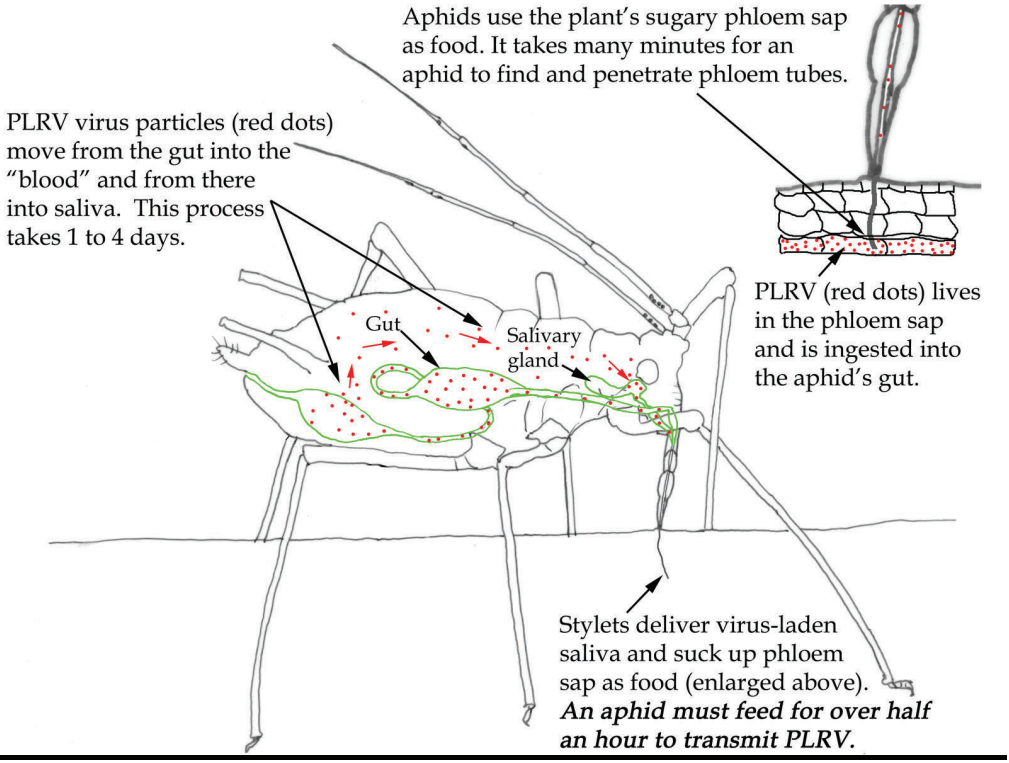
PLRV causes tuber net necrosis in some cultivars under some conditions. Net necrosis can develop and become more severe in storage.

Management

1. PLRV is transmitted through a time-consuming and complicated process (see reverse). This means that only aphids that prefer potato as food are important vectors.
2. Controlling or preventing aphid infestations can greatly reduce PLRV spread within a field. Insecticide choice is critical because some can actually **increase** aphid numbers by eliminating predators, while others may act to increase risk of spider mite outbreak.
3. By far the best PLRV management practice is to limit PLRV sources by purchasing clean seed and eliminating volunteer potatoes and other PLRV hosts like nightshade.

Potato Leafroll Virus (PLRV)

PLRV is transmitted by aphids through a complicated process.



The only important PLRV vectors in the Pacific Northwest are green peach aphid (top), and potato aphid (bottom).

Bacterial Diseases: Blackleg

Note the black color - rhizoctonia stem canker is similar but causes brown lesions.

Plants that grow from infected seed often die shortly after emergence. Symptoms include:
*inky black stem below ground, sometimes extended far above ground;
*wilting of leaves or entire stems.

General Information

Causal Agent: *Pectobacterium atrosepticum, Dickeya* spp.
Biology: Blackleg begins with planting infected seed. Seed can be infected during seed production, handling, cutting, and planting. Infected seed pieces sometimes rot before emergence -- this is called seed piece decay. Not all infected plants produce symptoms, but can still pass the infection to progeny tubers and therefore into storage.
Distribution: Blackleg occurs everywhere potatoes are grown.

Management

1. Prevention is key.
2. Know your seed source -- healthy seed is critical.
3. Sanitize seed cutting equipment between lots by cleaning all soil and debris from cutting equipment and applying a disinfestant.
4. Plant well-suberized seed into well-drained soil of 50-58 degrees F.

Bacterial Diseases: Aerial Stem Rot

Infected stems become slimy and are a paler green color.

Leaves on infected stems are often wilted and turn yellow.

General Information

Causal Agents: *Pectobacterium atrosepticum, Pectobacterium carotovora* subsp. *carotovora, Dickeya* spp.

Biology: Bacteria that cause aerial stem rot are nearly everywhere in the environment. They are moved in irrigation water, in aerosols, and on insects. Crop debris and soil are often sources of these bacteria. Disease development is favored by dense canopies, warm weather, and long periods of leaf wetness. Bacterial reproduction can be **very rapid** under warm moist conditions.

Distribution: Bacterial aerial stem rot occurs everywhere potatoes are grown.

Management

1. The critical issue: limit optimal growing conditions for the bacteria.
2. Minimize long periods of leaf wetness.
3. Avoid overly dense canopies.
4. Carefully manage irrigation, especially avoiding excess irrigation during hot weather; plants cannot use as much water in very hot weather and excess moisture encourages bacterial growth.

Potato Late Blight

Tuber Late Blight

Tuber infection begins superficially, but can invade entire tuber. Sporulation can occur on cut or uncut tubers.

Management

1. Prevention is key
2. Harvest during dry weather
3. Tuber temperatures going into storage should be less than 68 F
4. Mancozeb and metiram fungicides on the soil surface late season may help prevent tuber infection
5. Foliar applications of phosphorous acid at harvest and in storage can reduce late blight tuber rot
6. Late blight infection often leads to other kinds of tuber rots in storage -- it is best to NOT STORE late blight infected potatoes, and there are no chemical treatments that will cure an infected pile of potatoes

General Information

Causal Agent: *Phytophthora infestans*
Biology: Pathogen of potato and a few related plants; infection encouraged by humid and wet conditions
Dispersal: Sporangia move in the wind; zoospores in water
Fungicide resistance: *P. infestans* is well-known to become resistant to site-specific fungicides used against it. Fungicides should be rotated frequently to prevent resistance.

Potato Late Blight

Foliar Late Blight

Leaf infections show areas of dead or dying tissue surrounded by a pale halo. Lesions are not delimited by leaf veins. Also, note the whitish sporulation of the pathogen around the dead tissue.

Stems are also infected, and show typical sporulation at high humidity and moderate temperature.

Field infections can start from infected seed or sprouts from volunteer plants.

Management

1. Prevention is key
2. Manage volunteer potatoes and cull piles
3. Plant healthy seed
4. Use a seed treatment containing mancozeb or other preventive fungicide
5. Treat with foliar fungicides according to recommendations of WSU
   (for eastern Washington, access the lateblight information line at: 800-984-7400)
6. Monitor fields carefully for late blight infections, especially early in season
7. Avoid planting potatoes in ground that is expected to be excessively wet,
   such as pivot centers and pivot overlaps

Rhizoctonia Canker and Black Scurf

Rhizoctonia Stem Canker

Stem lesions or cankers caused by Rhizoctonia on a potato stem. These usually occur near the soil line.

Foliar symptoms can also develop when lesions occur on stems. Often numerous stems will arise from the leaf axils near the base of the plant, giving the plant a bushy appearance.

Severe stem cankers can lead to production of tubers on aerial plant parts.

Girdling of underground stems can lead to curled and purplish apical leaves.

General Information

Causal Agent: *Rhizoctonia solani*

Biology and Dispersal: Pathogen of potatoes everywhere. Infection of young plants is encouraged by cool soil. *Rhizoctonia* is easily and commonly moved on seed tubers. Disease in the field is initiated by both soil-borne and seed-borne inoculum. Infected sprouts can be killed, leading to delayed emergence and weak plants. Triggers for formation of sclerotia, called black scurf, on daughter tubers are not well-understood.

Rhizoctonia Canker and Black Scurf

Black scurf, or raised black spots on tubers, sometimes is called "the dirt that won't wash off." Black scurf (seen here on Yukon Gold tubers) actually are overwintering structures, or sclerotia, of the *Rhizoctonia* fungus.

Black Scurf

This close-up photo shows how the sclerotia are tightly attached to the tuber's skin.

Black scurf can affect all cultivars, but is most serious to fresh-market potatoes because of quality loss. The black scurf on this red potato was found in the grocery store.

Management of Stem Canker and Black Scurf

1. Minimize seed-borne inoculum by purchasing seed with minimal black scurf.
2. Reduce sprout infection by minimizing the time from planting to emergence.
3. Crop rotation will help reduce the populations of *Rhizoctonia solani* that are specific to potato.
4. Certain fungicides applied to seed pieces or in furrow at planting can reduce stem canker and black scurf caused by *Rhizoctonia*.

White Mold

Symptoms and Identification

Stem damaged by white mold. 1. Water-soaked lesion, 2. Leaves wilting and dying.

Infected stems often have fluffy white mold, hence the name of the disease.

Sclerotium inside infected stem.

General Information

Causal Agent: *Sclerotinia sclerotiorum*
Biology: Pathogen of many crops and other plants. Survives winter and other adverse conditions such as pesticides as sclerotia in the soil. Sclerotia germinate in spring and produce tiny mushroom-like structures called apothecia, which produce ascospores that infect senescing tissues such as flowers. Infections of healthy tissue start from mycelial growth from infected dying plant tissue or directly from sclerotia in the soil.
Dispersal: New fields can be infected by ascospores blown with the wind, but the pathogen is extremely wide spread due to its wide host range and persistance in the soil.

White Mold

Life Cycle and Infection Process

Apothecia grow from soil in spring, and produce ascopores.

Ascopores move in the air and infect potato flowers.

Infected flowers drop onto healthy foliage where infection of stems begins.

Sclerotia form inside stems and overwinter in crop residue.

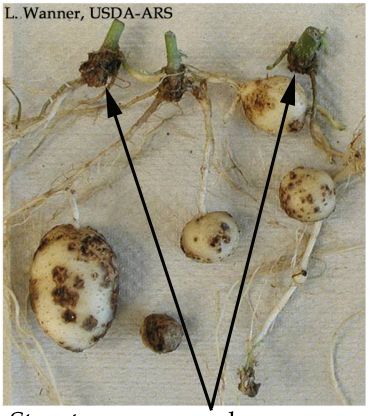
Management

1. White mold is most serious in fields with dense canopies, plenty of nitrogen fertilizer, and excess overhead irrigation; therefore --
   a. manage crop growth to limit canopy density, and
   b. avoid excess irrigation and long periods of leaf wetness.
2. Fungicide applications should be timed to coincide with full bloom of the primary flower clusters.

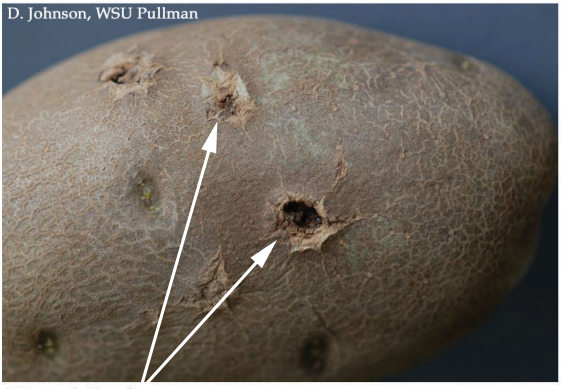
Common Scab

Typical superficial scab lesions.

Typical raised scab lesions.



Streptomyces can also cause callus-like lesions on underground parts of stems.



Pitted Scab
This type of symptom is more prevalent in some varieties than in others.

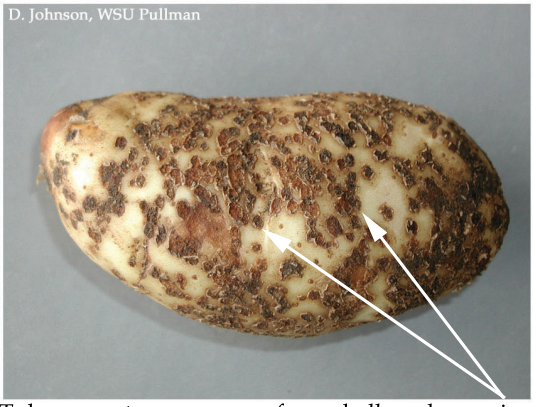
Management

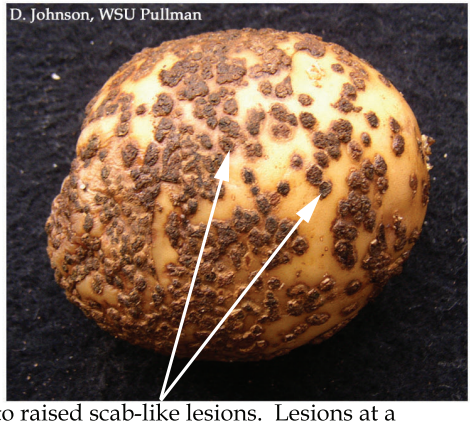
1. Reliable strategies are not known for scab prevention under all conditions (see below).
2. Avoid planting scabby seed tubers.
3. Plant varieties with scab resistance when possible.
4. Avoid application of soil amendments that increase soil pH.
5. A generally healthy crop may help reduce scab intensity on tubers.

General Information

Causal agent and biology: Common scab is caused by several species of *Streptomyces*, a genus of bacteria that is present in all soils in huge numbers. Most soils contain bacteria capable of causing potato scab, but exactly what conditions bring on symptoms is not fully understood. Scab-causing bacteria are constantly changing the arrangement of genes in their DNA, which may explain some inconsistency in field management.

Powdery Scab





Tuber symptoms can vary from shallow depressions to raised scab-like lesions. Lesions at a certain stage of development can be seen to be filled with powdery-looking structures called cystosori, hence the name of the disease, powdery scab.

Powdery scab can appear as galls on roots. These galls look something like galls caused by root-knot nematodes.
Severely affected root systems can result in foliar wilting & other above-ground symptoms.
Some potato varieties tend to have more symptoms on roots compared to tubers and vice versa.

Tuber symptoms of powdery scab and common scab (see reverse) are very similar, and both pathogens are sometimes found.

Management

1. Avoid planting infected seed into uninfested soil.
2. Follow good rotation practices of 3 or more years between potato crops.
3. Grow varieties that show less severe damage and symptoms in infested soil.
4. There are no effective foliar or soil-applied chemical control options.

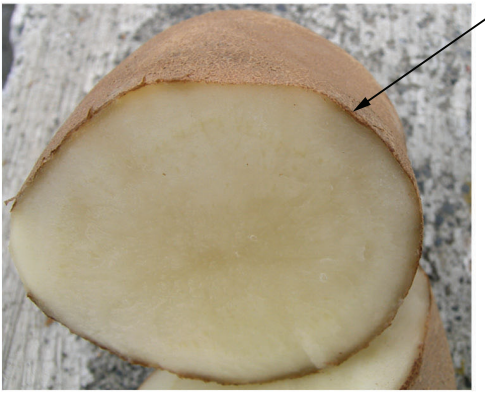
General Information

Causal agent: The protozoan called *Spongospora subterranea*.
Distribution: Powdery scab occurs in most potato producing regions in the world, and seems to be getting more prevalent in the Pacific Northwest.
Biology: *Spongospora* is a soil-inhabiting organism with a complex life cycle. It can survive in soil without hosts for several years; hosts include many solanaceous relatives of potato including nightshades.
Dispersal: *Spongospora* is easily moved to new locations on seed tubers or in soil.

Tuber Blemish Diseases: Black Dot

Brown, silvery, and sometimes pinkish lesions affect the periderm of the tuber, but rarely cause damage beneath the skin.

Small microsclerotia (overwintering structures) look like 'black dots' on the tuber surface, and are most easily seen with a microscope.



Management

1. Avoid planting infected seed.
2. Maintain good crop rotations of at least 3 years out of potato and other plants in the Solanaceae.
3. Maintain good crop fertility and soil health.
4. Promote good root health by not overwatering and avoiding soil compaction.

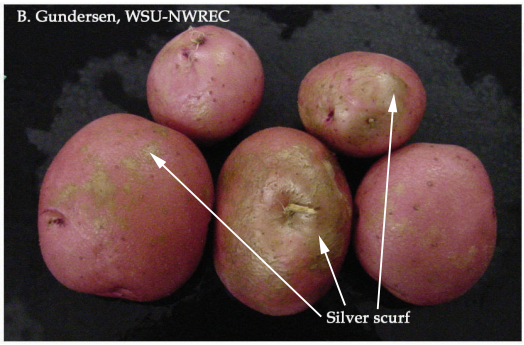
General Information

Causal agent: *Colletotrichum coccodes*

Biology: Pathogen of potato and relatives such as nightshades, tomato, and pepper. Overwinters in soil on plant debris or non-harvested tubers. Affected tubers occur consistently in some fields.

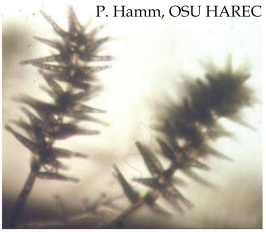
Dispersal: Seed tubers are commonly infected, and provide the most common way that black dot moves from field to field. Once soils are infested, they remain infested for some time.

Tuber Blemish Diseases: Silver Scurf



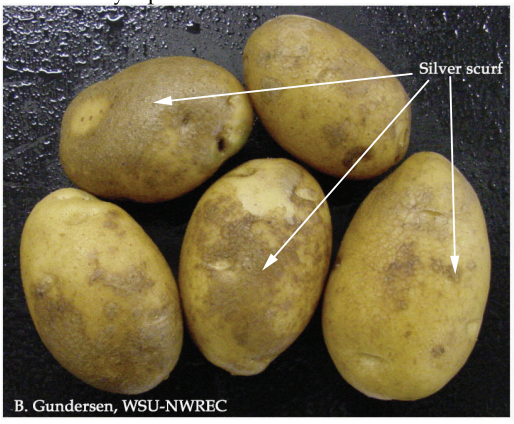
Symptoms on cultivar Chieftan

Silver scurf lesions can vary from brown to silvery grey in color, depending on potato cultivar.

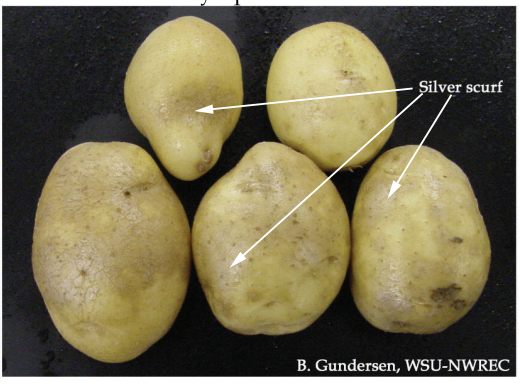


Silver scurf conidiophores on tuber surface bearing spores -- very different from black dot fruiting structures.

Symptoms on cultivar Russet Norkotah



Symptoms on cultivar Cascade



Management

1. Buy seed without silver scurf infections. If in doubt about your seed, have it tested.
2. Seed treatments containing thiophanate-methyl (e.g. TopsMZ) or fludioxonil (e.g. Maxim) can reduce infection on daughter tubers, but do not guarantee a clean crop if grown from heavily infected seed.
3. Disinfect storage buildings and all seed handling machinery.
4. Harvest soon after skin set to avoid infection of additional tubers.
5. Storage: avoid mixing lots with low and high infection rates; minimize storage time for infected lots; avoid opening & closing storage buildings containing infected lots.

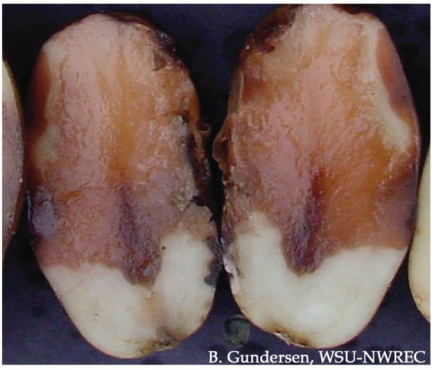
General Information

Causal agent: *Helminthosporium solani*

Biology: *H. solani* is a fungal pathogen of potato tubers, but can likely survive in the soil as a saprophyte. Infection occurs during the growing season from either seed-based inoculum, or from soil inoculum. Damage by silver scurf worsens during storage by spreading on and between tubers.

Dispersal: Silver scurf is distributed mostly on seed tubers, and is in fact commonly found on them. It is suspected to also move via contaminated soil.

Potato Pink Rot



***Symptoms often begin at the stolon end of the tuber.**
***Damage is sometimes bordered by a dark line visible on outside of tuber.**
***Recently infected tissue turns pink, and then black, when exposed to air.**
***Infections in storage may cause an ammonia-like smell.**

Management

1. Plant in well-drained fields without a history of the disease.
2. Avoid excessive irrigation late in the growing season, and do not plant in areas of fields expected to become excessively wet.
3. Avoid wounding during harvest and transfer to storage.
4. Harvest storage crops in cool weather and with cooler pulp temperatures.
5. Sort infected tubers at harvest, and process or ship affected lots promptly.
6. Some fungicides are active against pink rot, but take care to avoid encouraging fungicide resistance.

General Information

Causal agent: *Phytophthora erythroseptica*
Biology: Pathogen of potato and many other plants; present in many soils worldwide; tuber infection and decay is worst in warm and excessively wet soils.
Dispersal: Infection can spread from tuber to tuber during harvest and handling. Infected seed can also spread the disease.
Fungicide resistance: *P. erythroseptica* has begun to demonstrate resistance to fungicides. Fungicides should be rotated frequently to prevent resistance.

Pythium Leak

***Occurs wherever potatoes are grown.**
***This pathogen only enters through wounds.**
***There is usually a distinct line between healthy and diseased tissue.**
***Infected tissue is a smoky grey color.**
***When squeezed, infected tubers produce a dark watery liquid.**
***Following exposure to air, infected tissue changes from grey to brown, then black.**
***In storage, infected tubers are sometimes reduced to empty shells.**

Management

1. Crop rotation and destruction of diseased tubers are important.
2. Some fungicides applied at planting or during the growing season can reduce losses caused by Pythium leak.
3. Harvest with pulp temperatures between 45 and 65 degree F.
4. Minimize mechanical injury to tubers during harvest and handling.
5. In storage, encourage maximum suberization and wound periderm formation; do not allow free water on tubers.

General Information

Causal agent: *Pythium ultimum* and sometimes other *Pythium* species.
Biology: Wide host range including many crops. Infection of tubers occurs at wounds.
Dispersal: Infection can spread from tuber to tuber during harvest and handling. Infected seed can also spread the pathogen.
Fungicide resistance: *Pythium* has begun to demonstrate resistance to fungicides.