

Major Potato Diseases, Insects, and Nematodes



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C O N T E N T S

The International Potato Center (CIP) is a not-for-profit, autonomous scientific institution established in 1971 by agreement with the government of Peru. The Center develops and disseminates knowledge to facilitate use of the potato, sweetpotato, and Andean roots and tubers as basic foods in the developing world. CIP is one of 16 international research and training centers supported by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank, and comprises more than 45 countries, international and regional organizations, and private foundations.

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F O R E W O R D

This CIP manual, originally published in 1977, is an updated compendium of information describing major potato pests and diseases around the world. Correct identification is an essential first step in their control.

Each entry in this handbook is accompanied by photographs, and pinpoints where a specific pest or disease occurs. Additional information is provided on symptoms and recommended control practices. We anticipate that this publication will prove useful to researchers, extension agents, students, and farmers, and will assist them in controlling pests and diseases while safeguarding the natural environment needed for sustainable agriculture.

Peter Gregory
Deputy Director General for Research

Diseases Caused by Bacteria

Bacterial Wilt

BACTERIA

Pseudomonas solanacearum

Bacterial wilt or brown rot is the most serious bacterial disease problem of potato in warm regions of the world. It often limits production.

Symptoms. Initial wilting may affect one side of a leaf first, or one branch and not another (Photo 1). Mild yellowing usually accompanies wilting. Later symptoms are severe wilt and browning and desiccation of leaves, followed by death. Vascular strands darken and, when a cross section is made, a grayish white slime exudes, except in mild cases. This can be confirmed by the flow of milky white strands from a stem section placed just below the surface of a glass of still, clear water.

A grayish white bacterial slime may ooze through the eyes or stolon end of tubers, where soil adheres. Grayish white beads exude from the usually darkened vascular ring of cut stems or tubers (Photo 2). Aerial or tuber symptoms may occur alone, but the latter usually follow the former. Latent tuber infection occurs when infected seed is planted in cool locations or in tubers infected late in the growing season. Wilt develops rapidly at high temperatures.

Control. Crop rotation is most effective with the potato strain (race 3), but difficult with race 1 that also affects many other crops and weeds (especially Solanaceae). Diseased seed causes the most severe bacterial wilt infection and results in spread to noninfested soil. Spread also occurs via water flowing along rows and from field to field. Root-to-root contact also transmits the bacterium.

Soil survival in crop debris or survival free in soil vary considerably: usually 1 to 3 years for race 3, often longer for race 1. Self-sown tubers can increase survivability, as can growth in the rhizosphere of some crops and weeds.



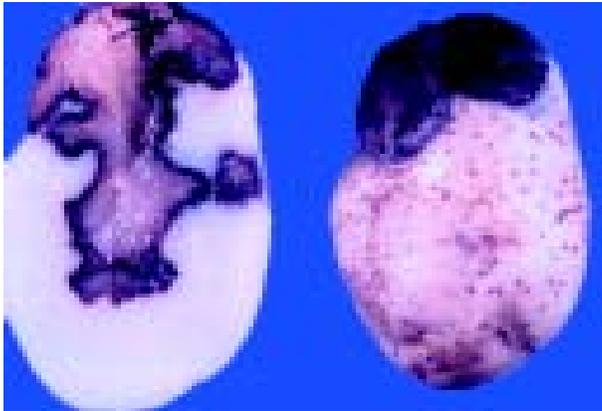
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Blackleg and Soft Rot

BACTERIA

Erwinia spp.

Blackleg of potato plants and soft rot of tubers are widely distributed diseases that are especially harmful in humid climates. *Erwinia carotovora* ssp. *carotovora* usually occurs in warm climates, *E. c.* ssp. *atroseptica* in cool climates, and *E. chrysanthemi* only in hot climates.

Symptoms. Blackleg can occur at any stage of development when moisture is excessive. Black, slimy lesions (Photo 3) most often progress up the stem from the soft, rotted mother tuber. New tubers sometimes rot at the stolon end (Photo 4). Young plants are commonly stunted and erect. Yellowing and upward rolling of leaflets may occur, often followed by wilting and death.

Soft rot bacteria may infect lenticels when tuber surfaces are wet, causing circular depressed areas, from which rot may spread rapidly while tubers are in transit or storage.

Soft rot in the field or in storage often follows mechanical tuber injury or injury caused by pests and diseases. Affected tissues become wet and cream to tan colored and soft, and are easily separated from healthy tissue.

Control. Avoid planting in wet soils and do not over-irrigate. Harvest tubers when ripe, handle them gently, and do not leave them exposed to sun. Tubers must be dry prior to storage or shipping. Some varieties are more resistant than others.

Ring Rot

BACTERIA

Clavibacter michiganensis ssp. *sepedonicus*

Bacterial ring rot is a recurring disease problem in temperate regions. It occasionally appears in tropical countries when seed from temperate regions is used, and can be confused with brown rot.

Symptoms. Symptoms usually appear mid-season or later and include wilting (often of only some stems of a plant). Lower leaves become flaccid, with a pale yellow color between major veins (Photo 5). An upward rolling of leaf margins may occur, and death may soon follow.

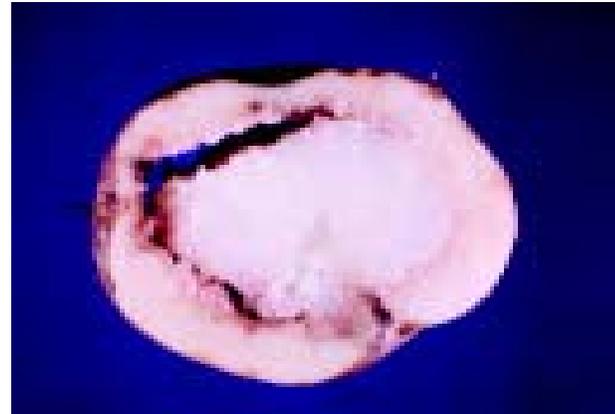
Stem and tuber sections show brown vascular rings that, when squeezed, may exude bacterial ooze. Most of the tuber vascular ring rots and turns either gray, yellowish, tan, or reddish brown. However, secondary organisms may cause a soft rot. Tuber infection can be confused with bacterial wilt (or brown rot) (Photo 6), except that oozing around the eyes does not occur.

Ring rot is mainly a seed tuber-transmitted disease. It survives in volunteer potato plants. The bacterium does not survive in the soil but may be carried on tools, machinery, crates, and bags.

Control. Plant disease-free seed. Eliminate volunteers in the field before planting clean stock. Follow strict sanitation practices and disinfect bins, equipment, tools, and crates. Use new bags. Plant entire (not cut) seed tubers.



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Common Scab

BACTERIA

Streptomyces scabies

Scab is a common tuber defect in most potato-growing regions, although usually not where soils are very acid. The causal organism has been introduced into most potato soils. It affects only quality, not yield.

Symptoms. Several types of lesions develop. They may be superficial or reticular (Photo 7, right), deep or pitted (Photo 7, left), or protuberant. They vary in size and shape, but are usually circular and not more than 10 mm in diameter. They may coalesce so that most of the tuber surface becomes affected. Fibrous roots may also be damaged.

Control. Maintain high soil water levels compatible with good potato growth during tuber set and enlargement. Avoid planting scabby seed tubers. Avoid repeated crops of potato or other scab-susceptible plants such as red beet, sugarbeet, radish, rutabaga, turnip, carrot, and parsnip (in these, the disease seldom has economic importance). Scab-resistant varieties are useful.

Maintain soil pH levels at 5 to 5.2 with acid-forming fertilizers or sulfur. Avoid heavy lime applications and preferably use dolomitic lime where needed. "Acid scab" may be controlled with chemical seed treatments (mancozeb dust, 8%) or soil fumigation.

Diseases Caused by Fungi

Powdery Scab

Spongospora subterranea

FUNGI

Powdery scab is present in all potato-growing areas in temperate zones and in the tropical highlands of Central and South America.

Symptoms. There are usually no aboveground indications of disease. Initial symptoms are small, light-colored, blister-like swellings on the tuber surface (Photo 8). At an advanced stage, these become dark, open pustules 2 to 10 mm in diameter or larger, containing a brown, powdery spore mass (Photo 9). Lesions are variable in shape, mostly roundish, and fringed by broken skin.

Root galls of up to 15 mm across may form. In large numbers, they reduce plant vigor. When galls are newly formed, their color is similar to that of normal roots. Later, as galls disintegrate, the color rapidly darkens (Photo 10).

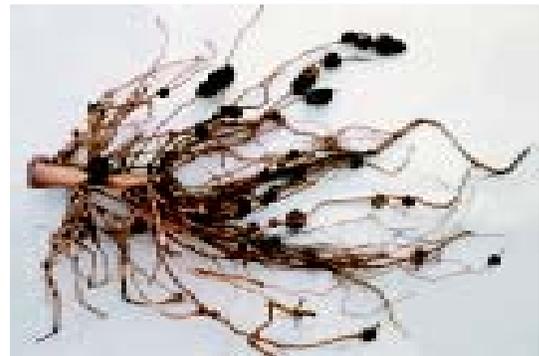
Control. A soil fumigation with methane sodium is reported to control powdery scab. Planting in well-drained soils free of disease and a long crop rotation with grasses where disease occurs may reduce incidence. Plant disease-free tubers. Resistant potato cultivars exist and should be used.



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Wart

FUNGI

Synchytrium endobioticum

Wart or black wart is widely distributed in temperate and high-altitude tropical regions with cold and rainy climates. It may cause considerable yield loss where races of the fungus occur for which resistance has not been introduced. The disease is often associated with powdery scab and does not develop in warm or dry soils.

Symptoms. Tumors of any size up to several centimeters may develop on stems, stolons, and tubers (Photos 11 and 12). Symptoms usually develop below-ground, but under wet conditions they may appear on stems and foliage. Initially, tumors are white to brownish or of the same color as normal tissue. Tumors blacken with age and may rot because of secondary organisms. Aboveground warts are green, reddish, or purple, depending on variety.

Control. Varieties that are resistant to races of the fungus should be used. Reduce wart incidence with long crop rotations (5 years or more) in combination with resistant varieties. Prohibiting the shipment of tubers, particularly seed from infested regions, is effective in limiting disease spread.

Seed of resistant varieties grown in infested soil can spread the disease as well as movement of infested soil or manure adhering to tuber surfaces, farm machinery, or other equipment.

Late Blight

Phytophthora infestans

FUNGI

Although control measures exist, late blight remains the most serious fungal disease in most major potato production regions.

Symptoms. Water-soaked lesions appear on foliage that, within a few days, becomes necrotic, turning brown when dry or black when wet. Under damp conditions, white mildew-like sporulation is visible, especially on the lower surface of leaves (Photo 13). A pale yellow margin often forms around leaf lesions (Photo 14). Lesions on stems and petioles are black or brown. Stem lesions are brittle and stems frequently break at the point of the lesion. Under certain conditions, wilting can occur on stems with lesions.

Disease is favored by temperatures between 10 and 25°C, accompanied by heavy dew or rain.

Tubers infected by spores washed by rain from the leaves and stems into the soil have brownish surface discoloration (Photo 15). Sections cut through tubers show brown, necrotic tissues not clearly differentiated from the healthy portions (Photo 16). Later secondary rot organisms develop in blighted tissue and rots spread in storage.

Control. Sources of inoculum are neighboring fields of potato or tomato, volunteer plants, and cull piles. The last two sources can be removed. Soil survival occurs wherever the sexual stage (resting oospores) occurs as a result of the presence of both the A1 and A2 mating types, which can lead to early infections.



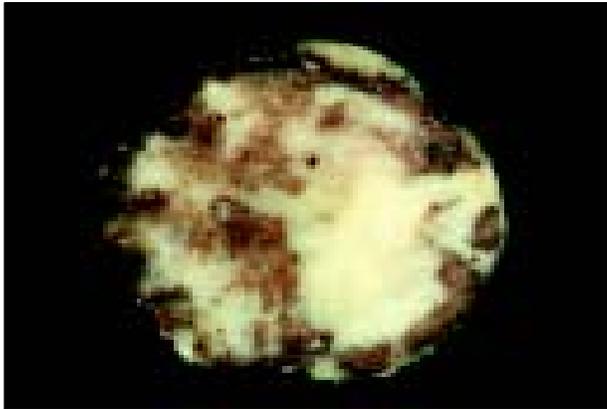
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Once infection occurs in a field, control is a function of host resistance and spraying, mediated by the environment. Growers should check with local extension agents for information on forecasting systems or spray schedules that maximize fungicide efficiency and resistance levels of cultivars. There are cultivars with various levels of resistance. Both protective and systemic fungicides are available, but the latter should only be used according to regional or national strategies that have been developed to minimize the development of resistance in the pathogen.

To prevent tuber infection, plants should be well hilled, foliage completely sprayed during the growth period, and vines permitted to mature and die naturally or be killed before harvest.

Pink Rot

Phytophthora erythroseptica

FUNGI

Pink rot is most severe at soil temperatures of more than 20°C in water-logged soils. It is generally not a major problem.

Symptoms. Although the disease may cause a wilt with stem decay and leaf chlorosis, usually only tubers have symptoms of dark brown, water-soaked discoloration and sometimes a rubbery texture (Photo 17).

The color change of cut tuber surfaces is characteristic. Within 5 to 20 minutes, these turn from a nearly normal color to pink and later to black. The rot is accompanied by a faint vinegar-like smell. Small lesions at harvest may go undetected but grow during storage, although the disease does not spread in storage.

Control. This soil- and seed-borne disease is enhanced by excessively wet soil conditions and is controlled by improving drainage. The disease can be eliminated by fumigating infested soil, complemented with metalaxyl 5G at planting time and the use of healthy potato seed tubers.



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Powdery Mildew

FUNGI

Erysiphe cichoracearum

Powdery mildew is widely distributed on many host plants and develops on potato under arid conditions with high humidity.

Symptoms. Old infections superficially resemble late blight as leaves turn black, die, and drop from the plant. Stems may also be infected. Initially, infected leaves are covered with whitish spore masses resembling soil residues (Photo 18), dust, or spray deposits.

The disease requires high humidity, but seldom develops where water falls on the leaves as rain or sprinkler irrigation.

Control. Where the disease is severe, biweekly applications of liquid sulfur formulations may be necessary.

Early Blight

Alternaria solani

FUNGI

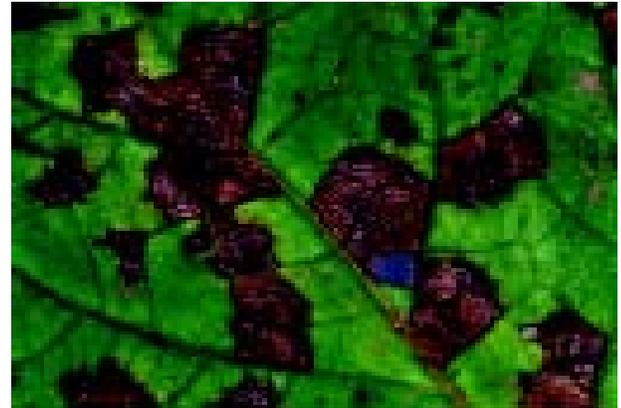
Early blight or *Alternaria* blight is worldwide in distribution and is one of the most important foliage diseases in areas with favorable weather conditions.

Symptoms. Brown, angular, necrotic spots marked internally by a series of concentric rings form on leaves and to a lesser extent on stems. Leaf lesions are seldom circular because they are restricted by the larger leaf veins (Photo 19). Lesions usually develop around flowering time and become increasingly numerous as plants mature. Lesions first form on lower leaves. They may join and cause general yellowing, leaf drop, or early death. Tuber rot is dark colored, dry, and leathery (Photo 20).

Susceptible varieties (usually early maturing) may show severe defoliation. Later maturing varieties may appear resistant. Plants under stresses that hasten maturity (such as adverse environment, warm, humid weather, other diseases, or nutritional deficiency) become susceptible and die prematurely.

Control. Provide conditions for vigorous growth throughout the season, especially irrigation and fertilizer side dressing. Organic fungicides sprayed on the foliage reduce the spread of early blight.

Resistance is available among late-maturing varieties.



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White Mold

FUNGI

Sclerotinia sclerotiorum

This disease affects potato mainly in the cool tropics and temperate zones. But it causes major damage to potato when the rotation includes susceptible vegetable crops (beans, lettuce, tomato, celery, cauliflower, cabbage). It is favored by cool, moist weather.

Symptoms. Stem lesions develop at the soil line or near leaf axils and are slightly sunken, oval, or elongated, extending up the stem. Initially, lesions are water-soaked, later becoming tan colored, white at the center, and ringed or zonate. Affected stems are covered with a white mycelial mat.

The central pith is destroyed and the hollow becomes filled with white mycelium that later forms hard, black, 0.5 to 1.0-cm-long sclerotia (Photo 21). Tops may wilt and stalks split or break at the soil surface.

Tubers near the soil surface become shrunken, superficially blackened, and watery. Cavities lined with black dead tissue later fill with white mycelium and sclerotia (Photo 22).

Sclerotia germinate, forming mycelial mats or small, fleshy, cup-shaped mushrooms from which air-borne spores disseminate and infect the leaves and stems of many dicotyledonous crops and weeds.

Control. The long-lived sclerotia can be killed by flooding for about 5 weeks. Rotations with nonsusceptible crops, including potato only every third year, along with removal and destruction of infected plants, help reduce this disease. Avoid overhead irrigation.

Stem Rot

Sclerotium rolfsii

FUNGI

Stem rot, southern blight, or *Sclerotium* rot occurs worldwide and attacks a wide range of plants, but is a problem for potato only under hot, moist conditions.

Symptoms. Initially, daytime wilting and yellowing result when brownish lesions girdle the stem base just below the soil line. A white mycelium grows on stems, tubers, or soil, often in fan-like mats, which produce small, initially white, but later brown, sclerotia, similar in appearance to mustard seed (Photo 23). In rainy weather, the affected stem sloughs off, leaving only the vascular tissue of the xylem, which leads to stem collapse.

Tubers may rot in the field before harvest, in storage, or in transit. They first form a cheesy semi-firm decay (Photo 24), which is often invaded by soft rotting organisms. Seed tubers may decay before plant emergence.

Control. Sclerotia are long-lived and many crops are susceptible to *S. rolfsii*. Control is difficult when conditions favor disease. Either plow deeply to bury affected plants and crop residues or remove them from the field and burn or bury them. Avoid plant debris around potato stems. The pathogen is highly aerobic; therefore, deep plowing and rotation with paddy rice are effective.

Harvest during dry weather.



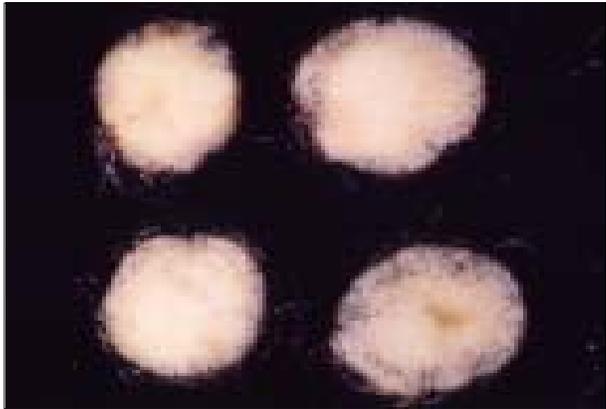
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Black Rot

Rosellinia sp.

FUNGI

Black rot, in higher tropical altitudes, may cause heavy potato yield losses in moist soils rich in organic matter (recently cleared land) and may affect other crop and weed hosts.

Symptoms. Diseased plants are stunted and wilt. Underground organs develop a black rot partially covered by matted strands of grayish white mycelium (Photo 25). The blackened tubers in cross section show a band of striate projections penetrating into the flesh (Photo 26).

Often, only isolated plants are affected or the disease occurs in patches in the field. Only during lack of crop rotation does the disease become a major problem.

Control. Removal or burning of brush and trees when land is cleared and subsequent crop rotation are recommended control measures.

Stem Canker and Black Scurf

FUNGI

Rhizoctonia solani

The fungus causing stem canker and black scurf is present in nearly all soils because it has a wide host range, survives in plant debris, and as sclerotia is easily disseminated on tubers. It grows over a wide range of temperatures. It causes considerable damage to emerging sprouts when conditions do not favor rapid emergence, such as cold and wet soil.

Symptoms. Lesions on sprout tips cause delayed emergence or failure to emerge. Slightly sunken brown cankers of variable size and shape affect stolons and stems at or below the soil line. Cankers may girdle stems and result in aerial tuber formation, plant wilt, and death (Photo 27). Girdled stolons may fail to produce tubers.

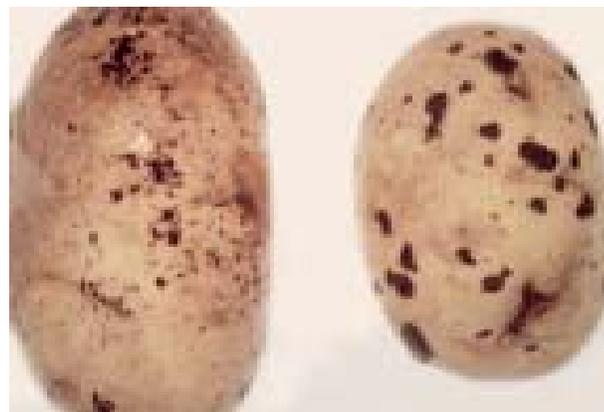
Hard, dark brown or black sclerotia (fungus-resting bodies) of irregular size and shape form on the tuber surface (Photo 28). A white mycelial mat may develop on the stem base, but does little harm to the plant.

Control. Because sclerotia are long-lived in the soil, only long rotations with cereals and grasses reduce disease incidence. Shallow planting of well-sprouted tubers reduces the exposure time of sprouts in the soil.

The disease can be reduced by applications of soil fungicides such as PCNB (pentachloronitrobenzene) mixed into the planting band of soil. Seed tuber treatment effectively reduces seed-borne inoculum when soils are not heavily infested. *Trichoderma* and binucleate *Rhizoctonia* used as biological control agents reduce severity.



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Fusarium Dry Rot and Wilt

FUNGI

Fusarium spp.

Different *Fusarium* species distributed worldwide cause various problems. Warm temperatures favor this disease.

Symptoms. Dry rot is one of the most serious storage problems. Tubers initially have dark, slightly sunken lesions that later expand superficially, leaving internal cavities that may contain different colored mycelia, depending on the species involved. The margin of the rot is clearly defined. Concentric rings appear on the tuber surface (Photo 29) and external mycelium is evident. The tuber dries and hardens. Under humid conditions, secondary soft rot develops.

Infection originates in surface wounds during harvest and handling. It can be reduced by initial curing at about 15°C and 95% relative humidity to promote wound suberization, prior to cold storage.

Improperly suberized cut seed decays under adverse soil conditions. Plants may fail to emerge, or be weak and subsequently wilt and die.

Fusarium wilt fungi are soil-borne. Symptoms are yellowing of lower leaves, chlorotic mottle of upper leaves, and subsequent wilting (Photo 30). Vascular tissues of stems and tubers become discolored. Tubers show several types of internal and external discoloration such as brown sunken necrosis at the stolon attachment or eyes, and circular brown rotted areas. Warm weather enhances wilt.

Some *Fusarium* strains become systemic and are seed transmitted.

Control. Use disease-free seed, good water management, and crop rotation. Treat cut seed with chemical protectants.

Verticillium Wilt

Verticillium albo-atrum, *V. dahliae*

FUNGI

Verticillium wilts may be a serious problem in tropical and subtropical regions and irrigated deserts where water deficiency may be severe. *V. dahliae* is more severe during prolonged warm, dry weather in cooler regions.

Symptoms. The disease is characterized by leaf yellowing, which begins at the plant base and may develop unilaterally, restricted to the sides of leaves, the stem, or the plant (Photo 31). Later, the plant may wilt. The vascular system of the lower stem turns brown. Plants frequently become yellowed and mature early without pronounced wilting (early dying).

Stems wilted by *V. albo-atrum* are blackened by the presence of a blackish resting mycelium. However, when *V. dahliae* causes wilting, the lower portion of the stem becomes grayish because of the presence of microsclerotia.

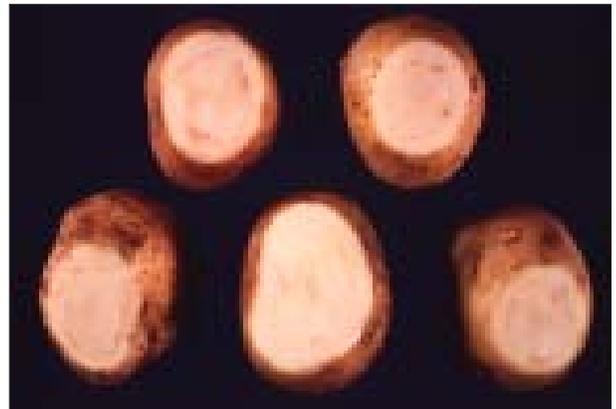
The vascular ring of tubers may have light brown discoloration extending from the stolon end up to more than halfway through the tuber (Photo 32). Larger tubers often have light tan, discolored eyes (pink eye).

These fungi are long-lived in soil or plant debris and have a wide host range, including other solanaceous plants, cotton, and weeds. Surface-borne inoculum on seed tubers is important in disease spread. Interaction with nematodes (*Meloidogyne*, *Pratylenchus*, *Globodera*), fungi (*Rhizoctonia*, *Colletotrichum*, *Fusarium*), and bacteria (*Erwinia*) increases damage.

Control. Use crop rotations with nonsusceptible cereals, grasses, or legumes. Resistant or tolerant potato varieties are available. Treat seed tubers with disinfectant fungicides to remove soil-borne inoculum. Prevent water stress by irrigation. Systemic fungicides are useful.



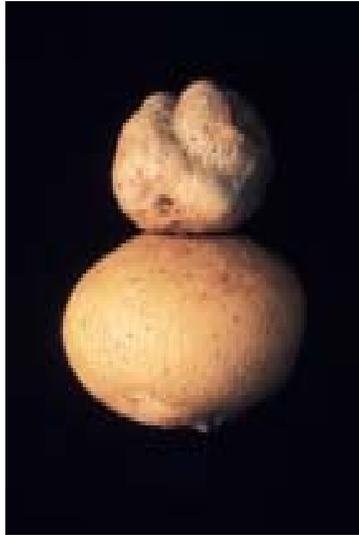
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Thecaphora Smut

FUNGI

Thecaphora (Angiosorus) solani

Potato smut is restricted to the tropical regions of the Americas. It occurs in cool highlands and irrigated coastal deserts, where it may cause serious problems. Little is known about its biology. Extreme care must be taken to avoid spreading the disease. Therefore, do not move infected tubers or infested soil to disease-free areas. Occurrence of this disease should be carefully recorded.

Symptoms. Symptoms are tuber-like outgrowths of stems and stolons that contain numerous small cavities filled with brown to black spores (Photo 33). Tubers may contain small, inconspicuous superficial pustules with a few spore-filled cavities or large protuberances (Photo 34). Single plants and even single stolons may carry tuber-like outgrowths as well as healthy-appearing tubers. After maturity, diseased outgrowths disintegrate rapidly into masses of brown spores. Certain potato cultivars such as Antarqui show protuberant lesions 3-10 mm in diameter on the tuber surface. After 2-3 months of storage, these lesions become sunken and subsequently hypertrophied tissues develop in the new sprouts or close to them. *Datura stramonium* (jimson weed) is a sensitive and propagative host.

Control. Dissemination is probably by infected or contaminated seed and soil. Resistant or tolerant varieties exist. Crop rotations are useful although the fungus persists in fields for many years. Strict quarantine should be enforced to prevent spreading the disease to new areas. Fumigation of infested soil, complemented with the use of healthy potato seed tubers of resistant potato cultivars, can eliminate the disease.

Diseases Caused by Viruses

Potato Leafroll Virus

(PLRV)

VIRUS

PLRV is the most important potato virus and is common in all countries. Yield losses in highly susceptible cultivars can reach 90%.

Symptoms. Primary symptoms caused by current-season aphid-transmitted infection are rolling of upper leaves, especially of leaflet bases. These leaves tend to be upright and are generally pale yellow. With many cultivars, they are tinged purple, pink, or red. Late infections may not cause symptoms, whereas some cultivars are infected symptomlessly. Tubers of highly sensitive cultivars develop net necrosis in the flesh.

Secondary symptoms (of plants grown from infected tubers of subspecies *tuberosum*) are rolling of basal leaves, stunting, upright growth, and paleness of upper leaves (Photo 35). Rolled leaves are stiff and leathery, and sometimes tinged purple on their undersides.

Subspecies *andigena* reacts differently: it develops marginal and interveinal chlorosis, especially of upper leaves, marked upright growth, and often severe stunting (Photo 36). Rolling of lower leaves is usually lacking.

Natural transmission is by aphids in a persistent manner, and through infected tubers.

Control. PLRV can be controlled by selecting healthy plants and eliminating diseased plants through roguing in seed propagation. Systemic insecticides will decrease spread by aphids within the crop but will not prevent infection by viruliferous aphids from other fields. PLRV is the only potato virus known to be eliminated from tubers by heat treatment. Resistant cultivars have been developed recently.



3 5



3 6



37



38

Potato Viruses Y and A (PVY and PVA)

VIRUS

PVY is the second most important potato virus. It is perpetuated through infected tubers and transmitted by aphids in a nonpersistent manner. Yield losses may reach 80%.

Symptoms. Symptoms vary widely with virus strain, cultivar, and environmental conditions. Rugosity, bunching, twisting of leaves, downward turning of leaflet margins, stunting, necrosis of leaflet veins, necrotic spotting, leaf necrosis, and stem streak (Photo 37) are typical. Less sensitive cultivars may react by developing with only a mild mosaic (Photo 38), or they may be infected symptomlessly.

PVA is in many respects similar to PVY. When present in certain cultivars, it is generally less severe than PVY. Yield losses may reach 40%. PVA causes mosaic (sometimes severe), as well as rugosity and crinkling, and leaves may appear shiny. PVA symptoms are usually milder, but cannot be easily distinguished from those of PVY.

Control. Control of PVY and PVA is by clonal selection and roguing in seed propagation. Resistant cultivars are available.

Mosaics

VIRUS

(PVX, PVS, PVM, also PVY and PVA)

Mosaic symptoms may be caused in potato leaves by several different viruses, singly or in combination. Some of these are potato virus X (PVX), potato virus S (PVS), and potato virus M (PVM), as well as PVY and PVA.

PVX may cause yield losses above 10%, with the extent varying according to strain and potato cultivar. It is transmitted through infected tubers and by contact (not by aphids), and normally causes mosaic (Photo 39). Infection may be mild in some cultivars and is frequently latent. Virulent strains may cause crinkling. Some cultivars are hypersensitive to certain strains and react with top necrosis.

PVS is common and may cause mild symptoms. It has little effect on yield. It is transmitted through infected tubers, by contact, and by aphids in some strains. Infection is normally latent although some cultivars react with mild mosaic or faint vein banding. A few sensitive cultivars react with severe bronzing, necrotic spotting, or even leaf drop.

PVM is less common than PVY, PVX, or PVS, and little is known about its effects on yield. It is perpetuated by infected tubers and transmitted by contact and by aphids. The virus is latent in some cultivars although in others it causes a mild mosaic or even a severe mosaic and leaf crinkle. Under certain environmental conditions, sensitive cultivars may also develop necrosis of petioles and leaf veins.

Control. PVX, PVS, and PVM are controlled by clonal selection during seed multiplication. Roguing is useful only when obvious symptoms develop. Cultivars resistant to PVX are available.



39



40

Andean Potato Mottle Virus

(APMV)

Andean Potato Latent Virus

(APLV)

VIRUS

APMV and APLV are frequent in the Andean region and are transmitted readily by contact and to an unknown extent by insect beetle vectors.

Symptoms. APMV normally produces mild to severe mottle (Photo 40). Sensitive cultivars may react with top necrosis, leaf deformation, and stunting or delayed emergence. APLV is usually latent but frequently causes minor chlorotic vein netting, or mild mosaics and rugosity.

APLV is transmitted by potato flea beetles (*Epitrix* spp.) and APMV by *Diabrotica* leaf beetles. Effects of these viruses on yield are unknown, but are more noticeable with APMV in sensitive cultivars.

Control. APLV and APMV are best controlled by clonal selection in seed propagation and by roguing.

Potato Mop-Top Virus (PMTV)

VIRUS

PMTV occurs in areas with cool, damp conditions that favor spread of its fungus vector, *Spongospora subterranea*. In sensitive cultivars, yield losses may reach 25% and tubers may become unsaleable.

Symptoms. Primary symptoms develop on and in tubers of some cultivars when they are infected directly from the soil. Symptoms consist of rings on the surface, sometimes brown and necrotic, extending as arcs into the tuber flesh (Photo 41). A powdery scab lesion (the source of infection) is in the center of this necrotic mop-top virus ring.

Vine symptoms are secondary and are of three types: bright yellow markings (aucuba) (Photo 42), especially on lower leaves; pale V-shapes (chevrons) on upper leaves; and stunting of stems (mop-top). The bright yellow markings consist of blotches, rings, and diagnostic V-shapes. Usually, only some stems on a plant are infected so that an affected plant also has normal-looking stems.

Only sensitive cultivars develop mop-top and severe secondary tuber symptoms, the latter consisting of malformation, gross cracking, fine surface cracking, and blotching and/or brown rings associated with the stolon end.

The virus survives in soil and spreads to new areas mainly through resting spores of the fungus vector, carried in soil or on seed tubers. Transmission through infected tubers is erratic.

Control. Treatment of infected soil with calomel, sulfur, or zinc oxide can inhibit infection of a healthy crop. Roguing is useful with cultivars that produce strong symptoms.



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4 4

Calico and Aucuba Diseases

(AMV, PAMV, TRSV, PBRSV, TBRV)

VIRUS

The importance of these diseases, which usually occur under cool conditions, depends on the causal virus and the cultivar.

Symptoms. Similar symptoms can be caused by several different viruses, including alfalfa mosaic (AMV) (Photo 43), potato aucuba mosaic (PAMV), tobacco ringspot (TRSV), potato black ringspot (PBRSV) (Photo 44), and tomato black ring (TBRV). Symptoms consist of bright yellow markings on leaves as spots, blotches, flecking, and/or yellowing around veins. In some instances, leaflets may be completely yellow.

Yield losses may occur and some causal viruses can severely affect tuber quality, causing necrosis and/or blotching.

Control. Control is by roguing during seed production and through application of chemicals to kill the vector of the virus in question: aphids for AMV and PAMV, and nematodes for TRSV and TBRV.

Potato Yellow Vein Disease

VIRUS

This disease is common in some countries in South America. It is apparently caused by a virus transmitted by the whitefly *Trialeurodes vaporariorum*.

Symptoms. Soon after infection, bright yellowing of minor veins (tertiary) is evident. As disease progresses, secondary veins and leaf lamina become yellow, usually leaving primary veins green (Photos 45 and 46). Stunting or weakness of the plants have not been detected, but tuber yield can be reduced by 50%.

Secondarily affected plants show vein yellowing right after emergence.

Control. Attempts to control the vector by pesticide applications have led to an increase in disease incidence because populations of natural biological control are affected. Elimination of infected potato plants in and around fields, as well as weeds such as *Solanum nigrum* and *Lycopersicon* sp., reduces sources of infection. The practice of interplanting beans with potatoes should be avoided because populations of the vector increase in beans.

Planting seed potatoes produced in areas where the disease does not occur also prevents having sources of infection for the potato crop.



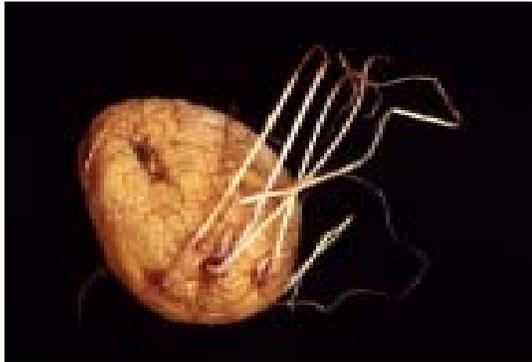
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48



49

Disease with Mycoplasma Pathogens

Purple Top Wilt

MYCOPLASMA

(Aster Yellows, Stolbur, Haywire)

These diseases, caused by mycoplasma-like organisms that resemble bacteria that lack a cell wall and are thus of indefinite shape, can severely affect yield and tuber sprouting and quality. They are transmitted by leafhoppers.

Symptoms. Symptoms include development of shoots and/or aerial tubers in leaf axils (Photo 47). Plants become stunted and apical leaves may curl and turn yellowish or purplish. Plants may wilt. Tubers from infected plants do not sprout normally. They are often small, flaccid, malformed, and without sprouts or with thin "hair sprouts" (Photo 48).

Witches'-broom is a symptom caused by another strain of mycoplasma (Photo 49).

Although these diseases are usually of minor importance in potato, being current-season problems only, hundreds of species of vegetable, ornamental, and field crop plants and weeds are susceptible to them.

Control. Leafhoppers cannot acquire the pathogen from potato, and they can be partly controlled by killing weed hosts from which these vectors move to the potato crop. Leafhoppers can often be avoided by planting later in the growing season after their migration has ended. The principal leafhopper vectors develop on convulvaceous weeds, grasses, and small grains.

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Diseases with Adverse Environments

Oxygen Deficiency

ABIOTIC

Oxygen requirements of tubers are fairly high at 0°C, and least at 5°C. They increase up to 16°C and are high at 25°C and above. Therefore, oxygen deficiency of cells in the tuber center can occur at temperatures either too low or too high. Injury develops in both the field and storage, particularly if air movement is restricted around tubers. Rapidly growing tubers have high oxygen requirements.

Black heart—blackening of the tuber center (Photo 50)—follows acute oxygen deficiency associated with either low temperature in confined storage or high field soil temperatures. Affected tubers rot later.

Internal heat necrosis, a field problem (Photos 51 and 52), is a less acute high-temperature injury in which groups of cells become rust-colored, particularly in the centers of large tubers. Internal heat necrosis is often severe in sandy or mucky soils exposed to solar heat following early vine death and delayed harvest. Rot is usually not a severe problem.

Tubers with oxygen deficiency symptoms should not be used as seed. Avoid high field soil temperatures by harvesting promptly after vines are killed. Maintain cold storage at 4°C or slightly higher. Improve aeration in storage.



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Low-Temperature Injury

ABIOTIC

Frosted leaves turn brown and become black when wet (Photo 53). Upper parts of the plant freeze first. Plants in spotted areas of the field, often low areas, may be the only ones damaged. Plants usually recover from early-season injury although yields may be reduced.

Leaf primordia may be injured following low temperatures that do not actually freeze tissue. Leaves forming after such an injury may be distorted (Photo 54), have yellowish spots or areas, or contain holes.

Upon thawing, frozen tubers are soft and spongy and water leaks from wounds and eyes. Cut cross sections turn pink, later become dark-colored (Photo 55), and rot. Frozen tubers when dried are firm and appear chalky.

Prolonged low-temperature storage, slightly above freezing, may cause a sweet flavor in cooked potatoes. Many varieties once stored at low temperatures retain sugars that cause a dark color when fried. Other types of injury include: tissue—smoky gray to black (Photo 56); vascular ring—gray to black; sometimes black pinpoint spotting throughout the tuber but more severe in the vascular ring; and net necrosis (Photo 57). Affected tubers at warmer temperatures often soft rot.

Do not use tubers with low-temperature injury for seed. Frost-resistant varieties are being developed.

Tuber Growth Abnormalities

ABIOTIC

Excessively rapid tuber growth, especially during favorable water and soil fertility conditions, causes internal cavities and hollow heart (Photo 58). Rots seldom follow although market quality is reduced.

Knobbiness and irregular shape—second growth (Photo 59)—results when tubers resume growth because of improved environmental conditions after the tuber's initial expansion under less favorable conditions. One example is water following drought. Tissue around the apex may resume growth, causing an enlarged end. Lateral eyes enlarge to produce knobs.

Heat sprouts occur when sprouts develop from tubers that have suffered from high temperatures and grow either as a sprout or a leafy aboveground stem (Photo 60). Tuber chaining (Photo 61) occurs when a series of secondary tubers develop on a single stolon.

Resumption of tuber growth following quiescence is often accompanied by carbohydrate translocation from the basal part to another part of the same tuber, leaving a wet, soft mass, jelly end rot (Photo 62). Also, carbohydrates may move from one tuber to a different tuber more terminally situated on the same stolon. When this or jelly end rot occurs, market quality is greatly reduced.

Some varieties are more prone to injury than others. Space plantings to avoid excessively large tubers and to promote uniform stands. Regulate water supply to provide uniform growing conditions.



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Tuber Cracking and Bruising

ABIOTIC

Tuber cracking can be classified into four types: (1) growth cracks from internal pressure (Photo 63), (2) growth cracks from virus infection (Photo 64), (3) mechanically produced cracks (Photo 65), and (4) harvest cracks. Growth cracks from internal pressure occur because of rapid tuber growth; potato cultivars differ in susceptibility to this type of cracking. Cracking and bruising injury occurs at harvest when tubers are dropped or partially crushed. It is severe when turgid tubers on vigorous vines are harvested from cold soil.

Handle freshly harvested tubers with great care. Permit soil to warm before harvesting tubers, and store them initially at appropriate curing temperature and humidity (about 15°C and 95% relative humidity).

Chemical Injury

Commercial fertilizers improperly applied injure seed tubers, causing rot, restricted root growth, burned foliage, or discolored tuber skins.

Herbicides often cause plant deformation, leaf distortion (Photo 66), chlorosis, necrosis (Photo 67), and stunting in the year of application. Tubers of the new crop may be distorted with necrotic tissue internally or externally. Effects can carry over in tubers from applications of the previous season. Accidental injury may result from herbicide treatment of nearby crops. Symptoms differ with the herbicide involved.

Insecticides and fungicides, or their carriers, frequently injure plant foliage when improperly applied. They burn leaves severely in areas between larger veins. Leaf margins may also be burned.



66



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Air Pollution Injury

ABIOTIC

Sulfur oxides typically cause chlorosis and bleaching or burning of leaves between major veins before killing the entire leaf. Photochemical oxidant air pollutants cause early maturity and death of the plant, beginning as yellowing and early death of lower leaves (Photo 68). Symptoms resemble those of senescence and poor nutrition. Air pollution may occur at a distance from the pollutant source and is often difficult to diagnose.

Nonvirus Leafroll

ABIOTIC

Potato leaves roll upward for several reasons, not necessarily because of virus leafroll (Photo 69). Varietal response to environmental factors—especially inadequate nutrition or intense light and long days—causes relatively uniform leafrolling throughout a field or a portion of it, in both symptom severity and time of onset.

Leafroll may also be due to genetic factors influencing the response of certain clones, and can cause variability in potato populations grown from true seed.

Rolling caused by improper plant nutrition is not fully understood. Mineral deficiencies involving minor elements and nitrogen toxicity are important. Aphid populations on the plant can cause toproll in the absence of the leafroll virus.

Nonvirus leafroll is not infectious and leafrolled plants usually yield well. Proper diagnosis of leafrolling is particularly important in seed programs.



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72

Nutrient Imbalance

ABIOTIC

Potatoes grow best in soils of pH 5.0 to 7.0. Deficiencies or toxicities of major or minor elements may be caused by excessive solubility or fixation in the soil through interaction with soil colloids or chemicals.

Nitrogen (N) requirements increase rapidly with plant growth. When N is translocated to upper leaves excessively from the lower leaves, they then become yellow (Photo 70). Later, if the deficiency is not corrected by fertilization, the entire plant becomes yellow and fails to grow properly. Severity of plant response depends on the level of N deficiency. N toxicity from ammonium or nitrites may follow degradation of nitrogen-containing fertilizers in certain soil conditions.

Phosphorus (P) deficiency follows P fixation in a wide range of soil types. Symptoms include retardation in growth of terminals; small, spindly, somewhat rigid plants with crinkled or cup-shaped leaves; darker than normal color (Photo 71); possibly a delay in maturity; and reduced yield. Tubers may have internal rusty brown necrotic flecks similar to internal heat necrosis. Because P is frequently fixed in the soil, fertilizer banding applications lateral to the seed piece are superior to broadcasting.

Potassium (K) deficiency is common in light, easily leached soils. Early symptoms are a dark or bluish green glossy foliage. Later, older leaves become bronzed and necrotic (superficially resembling early blight), and senesce early (Photo 72). Necrotic, somewhat sunken corky lesions form on the tuber surface, particularly at the stolon attachment. Tubers are predisposed to black spot, and when cooked tend to darken.

Nematodes

Cyst Nematodes

NEMATODES

Globodera pallida and *G. rostochiensis*

Cyst nematodes are a serious disease in some of the main potato-growing areas. Native to the Andes, they have now spread to some temperate zones and high-altitude tropics, where they can reduce yields substantially. Cyst nematodes also increase incidence of infection by bacterial and *Verticillium* wilt.

Symptoms. Specific symptoms do not appear in the aerial parts of the plants. Deficient growth, stunting, yellowing, and early senescence are common. Roots and sometimes tubers exhibit the only specific characteristic: the white or yellow spherical body (0.5-1.0 mm in diameter) of the females (Photo 73). These females gradually turn brown and become a cyst, which contains the eggs and may persist for several years.

Cysts are carried by soil sticking to tubers, farm machinery, tools, and containers, thus spreading the pest.

Control. Several measures reduce populations or damage caused by nematodes, including planting with resistant or tolerant varieties, long rotations, and fertilizing with high doses of organic matter. Nematicides protect young plants and increase crop yields, but nematode populations recover as plants mature. Soil fumigants have a similar effect.



73



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75

Root-knot Nematodes

Meloidogyne spp.

NEMATODES

Polyphagous root-knot nematodes occur principally in warm areas. Damage is particularly serious in sandy soils. Nematode attacks increase incidence of infection by bacterial wilt, *Verticillium*, and other pathogens. Potato cultivation in warm climates increases crop exposure to more severe nematode attacks.

Symptoms. Plant aboveground symptoms are not specific. Weak topgrowth and small, chlorotic leaves that wilt quickly in warm weather are typical. Infected roots show knots or galls of variable size depending on the extent of damage (Photo 74). Tubers may also become infected and show galls, deformations, or internal symptoms of nematode disease (Photo 75). Strong attacks cause the early death of infected plants.

Control. Nematode populations or damage can be reduced through different cultural practices, such as rotation with cereals, long fallow, tilling, and heavy doses of organic fertilizers. Treatment with soil fumigants is extremely costly. Nematicides may have a temporary positive effect.

False Root-knot Nematodes

NEMATODES

Nacobbus aberrans

False root-knot nematodes are widespread in cold Andean areas, in particular the southern Peru-Bolivia plateau. They cause severe damage under conditions of heavy infestation.

Symptoms. Aboveground plant symptoms are not specific. Infested plants are weak. Strings of galls in a beadlike fashion are typical of infected roots (Photo 76). Galls look similar to those of *Meloidogyne*, but this disease is spread over a different territory.

The nematode's ability to survive unnoticed under the skin of tubers and in the dry soil adhering to them contributes to the spread of the disease. False root-knot nematodes also attack some weed species and lesser known Andean crops such as oca (*Oxalis tuberosa*) and ulluco (*Ullucus tuberosus*).

Control. Rotations with cereals and long fallow periods reduce populations. Varieties differ in their tolerance, and fumigant treatments are effective, though extremely costly. Other nematicides may have a temporary positive effect.



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Lesion Nematodes

Pratylenchus spp.

Root-lesion nematodes, *Pratylenchus penetrans*, and no fewer than 10 other related species are found in temperate climates. Severe attacks can reduce yields substantially. Moreover, nematode lesions favor infection caused by soilborne bacteria and fungi.

Symptoms. Root-lesion nematodes are migratory endoparasites. High populations cause brown necrotic lesions in the cortical root tissue (Photo 77). Infected tubers show purple-brown pimples, pustules, or wartlike protuberances (Photo 78) that lower their market value. The plant's aerial parts generally develop poorly.

Control. Timely harvesting and cold storage reduce nematode damage. Infected tubers should not be used as seed. Seed tubers should receive a nematicide or hot water (50°C for 45-60 minutes) treatment.



77



78

Insects

Green Peach Aphid and Other Aphids

INSECTS

Myzus persicae and other *Aphididae*

Aphids occur in many different crops. They are small (1-2 mm), soft, and usually green. Winged individuals (Photo 79) start infestations whereas wingless aphids start colonies in the plant's young parts and back of leaves (Photo 80). Aphids suck the host's sap and weaken the plant; sugary excretions favor black fungal growth on the leaves. Aphids traveling from plant to plant are efficient vectors of viral diseases.

Symptoms. Aphid colonies can be easily identified in plant terminals and on the underside of leaves in the field. They also appear in tuber sprouts in stores, where they transmit viruses to seed potatoes (Photo 81). Insect eggs survive winter weather, but under less rigorous conditions aphids will reproduce viviparously throughout the year. Winged individuals travel long distances in the wind.

Control. The aphids' many natural enemies act as efficient biological control agents. Different predatory and parasitoid insects (such as coccinellid beetles and the *Aphidius* sp. wasp, respectively) also feed on aphids. Fungi such as *Entomophthora* sp. may cause their death. Chemical control should favor systemic products with a selective effect against aphids and a lesser effect on natural enemies.



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Thrips

INSECTS

Frankliniella spp., *Thrips* spp.

Thrips are thin, minute insects (1-2 mm long) that feed on cells on the underside of leaves. The plant thus weakens, its leaves dry, and yields drop. Severe attacks may cause wilting of plants. Thrips also transmit tomato spindle wilt virus (TSWV).

Symptoms. Pale or brown nymphs (Photo 82) and darker adults can be observed on the underside of leaves, where silver spots appear (Photo 83).

Control. Thrips populations increase in dry conditions; therefore, adequate irrigation is an effective control method. If populations persist, insecticides may be required.

Leafhoppers

Empoasca spp. and other genera

INSECTS

Leafhoppers are widely distributed. They are small (3 mm; Photo 84) and highly mobile. They feed on plant sap and weaken the plant. They also introduce toxins, thus further damaging the plant. Some species transmit mycoplasmal diseases such as aster yellows and witches'-broom disease.

Symptoms. Besides the presence of nymphs and adults on the underside of leaves, leafhoppers burn leaf edges with top leafroll and foliar yellowing. Plants may die prematurely.

Control. Infestation of potato fields may be prevented by avoiding proximity to crops such as beans that host high leafhopper populations. Resistant or tolerant varieties can be used, but if leafhopper populations increase, systemic insecticides may become necessary.



84

Potato Tuber Moths

Phthorimaea operculella, *Symmetrischema plaesiosema*, *Tecia solanivora*, and *Scrobipalpa absoluta*

Potato tuber moths attack potatoes in both fields and stores. They are widely distributed in warm, dry areas as well as in the high-altitude Andes. Damage is especially severe in warm, dry conditions, and more severe in stores in the absence of control measures. Adult moths are gray-brown and about 10 mm long. Larvae are off-white with greenish or reddish stripes depending on the moth species. They may be up to 12 mm long.

Symmetrischema plaesiosema (Photo 85, left) occurs in the Andean region from 2,000 to 4,000 m, where larvae bore through stems (Photos 86 and 87) and tubers (Photo 88) in the field. But they principally attack tubers in stores. *P. operculella* and this species commonly occur together.

Phthorimaea operculella (Photo 85, center) is widespread throughout warm, dry potato-growing areas. It may be found exceptionally in high zones up to 3,700 m. Moth larvae bore through the plant terminals and stems (Photo 89), mine the leaves (Photo 90), and bore through tubers in the field. Severe damage can occur in stores in a relatively short time (Photo 91). Infested tubers typically show larval excrement at the gallery entrance holes.

Scrobipalpa absoluta (Photo 85, right) is found in several South American countries in warm and/or low-altitude areas. Larvae damage only the leaves (Photo 92) and sprouts.

Tecia solanivora (Photo 93), commonly known as the Guatemala moth, is distributed in Central America, Venezuela, and parts of Colombia. Larvae damage only the tubers (Photo 94).



85



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86



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Control. Pest incidence can be reduced through cultural practices such as not planting potato in the warmest and driest seasons, controlling irrigation to prevent soil cracking that allows moths to reach the tubers, hilling-up to properly cover the tubers, using pheromone traps to capture and monitor field populations, and occasionally using a selective insecticide. Biological insecticide treatments such as *Bacillus thuringiensis* or *Baculovirus* should be used with tubers in stores, especially seed tubers. Likewise, repellent plants such as “muña” (*Minthostachys* spp., a plant native to the Andes), eucalyptus, or lantana help protect stored tubers.



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96

Cutworms

INSECTS

Agrotis spp. and other *Noctuidae* species

Cutworms are larvae of several noctuid moth species that cut through the stems of young plants. Robust and grayish larvae as long as 5 cm remain buried at the base of the plant during the day. Tubers closer to the ground surface may suffer occasional damage (Photo 95). Some species within the same family (cutworms) will preferably feed on the leaves (Photo 96). Spot and line patterns are generally apparent on the back of these larvae.

Control. Spotted or localized field infestations are typical, calling for focused insecticide treatments. Toxic baits prepared as a mix of bran, molasses, water, and insecticide should be applied at the base of plants at dusk.

Flea Beetles

Epitrix spp.

INSECTS

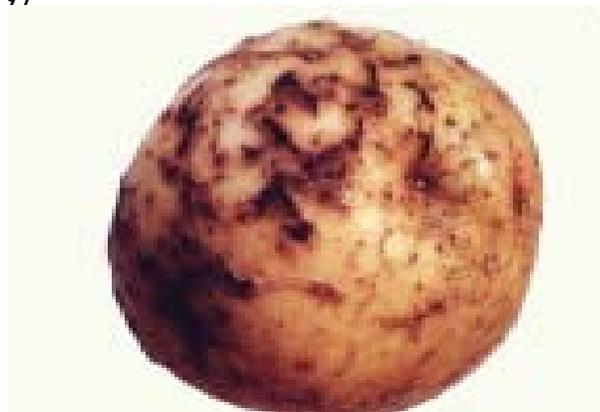
Flea beetles are small, 2-3 mm long, and black, and jump easily in the foliage of plants, where they bore circular holes less than 3 mm in diameter (Photo 97). Extreme damage may cause leaves to dry completely, thus affecting photosynthesis and plant yield.

Larvae that feed on roots, stolons, and tubers also cause damage (Photo 98). They bore the tubers superficially or scratch the skin, thus facilitating penetration of pathogen fungi found in soil. The white, thin larvae have short legs on the thorax and may measure up to 4 mm.

Control. Potato plants withstand some foliage damage beyond which insecticides are required. Removal of host weeds and appropriate soil preparation contribute to reducing flea beetle populations.



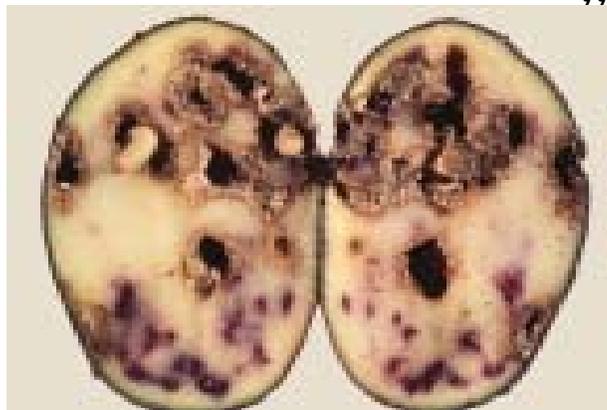
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100

Andean Potato Weevils or White Worms

INSECTS

Premnotrypes spp. and other related species

Andean potato weevils or white worms are native to the Andes. Several species of *Premnotrypes* and related genera cause similar damage. The adults (8-10 mm long) are dark brown and are easily confused with the soil. They hide underground during the day and feed on leaf edges at night (Photo 99). Economic damage to potato crops results from tunnels bored by the larvae in tubers in fields (Photo 100). Larvae may measure up to 12-14 mm. Once fully developed, they dig underground to overwinter. After going through the pupal stage, the insect becomes an adult weevil. Adults emerge from the soil at the beginning of the rainy season. Infestation of new fields by adults is more intensive around overwintering areas such as potato fields harvested the previous year and stores.

Control. A yearly calendar of control measures can help to effectively reduce infestations of the Andean potato weevil. Approximately a month after the harvest, the ground is plowed to destroy the larvae and pupae in the soil. A treatment with the fungus *Beauveria brongniartii* or larval insecticide is applied to the floor of stores. During crop growth, adults are collected in a container at night by shaking the foliage. At harvest time, tubers are placed on sheets to prevent larvae from penetrating the ground. Insecticides used at harvest and/or hilling-up have not always yielded satisfactory results.

Wireworms

INSECTS

Agriotes spp. and other *Elateridae*

Wireworms are frequent pests in temperate climates, but less so in warm areas. Thin, lustrous larvae with small thoracic legs (Photo 101) live underground and may be up to 25 mm long. The larvae produce irregularly shaped superficial tunnels in tubers (Photo 102), but they do not live inside the tuber.

Control. Wireworms feed on the roots of various crops, particularly pastures. Consequently, before planting potatoes in pasture areas, the soilborne wireworm larvae population must be reduced by proper plowing and rotation with other crops that require frequent tilling. Insecticides applied to soil may be required in certain circumstances.



101



102



103

White Grubs

INSECTS

Phyllophaga spp. and other *Scarabaeidae*

White grubs are the larvae of relatively large beetles. The white larvae may measure up to 5 cm. Their robust and curved bodies have legs in the thorax (Photo 103). Economic damage results from the deep holes larvae make in the tubers underground. Severe damage occurs when planting potatoes in former pasture or grazing fields.

Control. Potato should not be planted directly in pasture or grass fields. Deep tilling exposes worms to adverse environmental conditions such as sunlight and frost, and to predatory birds. This pest is not easily controlled with insecticides.

Mites

MITES

Tetranychus spp., *Polyphagotarsonemus latus*

Tetranychus (Photo 104) and other types of related mites are generally known as red spiders, although red is not always their characteristic color. Mites are extremely small, almost microscopic, and feed on the cellular matter of leaves. Chlorotic spots caused by mites give leaves a tan coloring, whereas high infestation will cause leaf and plant wilting.

Microscopic *Polyphagotarsonemus latus* (Photo 105), commonly known as white mite, attacks sprouts and tender leaves, deforming them. Damage to growing plants is particularly severe.

Control. Warm, dry conditions, insufficient irrigation, and excessive use of certain pesticides that destroy the mites' natural enemies must be avoided. Specific acaricides may be needed.



104



105



106



107

Leafminer Flies

INSECTS

Liriomyza huidobrensis and other *Agromyzidae*

Leafminer flies attack many crops. They are a serious potato pest in areas where they are associated with intensive use of insecticides that destroy their natural enemies. The flies are small (Photo 106) and their larvae bore tunnels inside the leaves (Photo 107), which dry up, eventually leading to plant death. The small larvae may measure up to 2.5 mm. They do not have heads or legs. The cocoons form on the underside of the leaves and then fall to the ground.

Control. Leafminer flies are commonly affected by a wide range of natural enemies. These biological control agents should be protected by avoiding early applications of broad-spectrum and long-lasting insecticides. The adults can be collected with sticky yellow traps. We must try to prevent damage from reaching the mid third of the plant before flowering. Products that are specific for adults or preferable for larvae (insect growth regulators) should be used when required.

Whiteflies and Other *Aleyrodidae*

INSECTS

Several species of the *Aleyrodidae* family generally known as whiteflies (Photo 108), though not actually flies, are pests to a number of crops. The small adult whiteflies can be easily seen on the underside of the leaves and they will quickly start fluttering at the slightest movement of the leaves. Nymphs are less easily identified. They adhere firmly to the underside of the leaves and weaken plants by feeding on their juices. A black fungus that grows on the honeydew produced by the nymphs will cover the plant. Plant infestation by whiteflies is often the consequence of biological imbalance resulting from the intensive use of insecticides.

Control. Measures should be aimed at restoring the natural equilibrium and fostering the whitefly's effective natural enemies. Thus, unnecessary use of insecticides should be avoided. It is also advisable to plant maize or sorghum on field edges or in alternating furrows to enhance the development of biological control agents. Sticky yellow traps can be used for population level evaluation and control. If needed, selective insecticides should be used.



108



109

Blister Beetles

Epicauta spp.

INSECTS

Adults of *Epicauta* spp. are 10- to 15-mm-long black beetles (Photo 109). Many species are known worldwide. They attack potato and occasionally other crops such as tomato, bean, pea, cabbage, maize, clover, and cotton. Attacks usually concentrate in certain areas of a field and only midribs of leaves may be left after adults feed.

Control. Several contact and ingestion insecticides are effective in localized applications.

Leaf Beetles

Diabrotica spp.

INSECTS

More than 300 *Diabrotica* spp. attack a wide variety of plants worldwide. Adult beetles are generally yellow-green with spots or stripes and are 6 to 8 mm long. They cause small feeding holes in leaves, similar to adult flea beetle damage (Photo 110), but the holes are somewhat larger. In some areas, the most important economic damage to potato is caused by the subterranean larvae gnawing the surface of the tuber, which loses quality and becomes susceptible to soil pathogens. Eggs and larvae do not develop under dry conditions so damage is most severe during wet seasons.

Control. In areas favorable to this pest, crop rotation should include nonhost plants. Contact and ingestion insecticides are effective against adults.



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P H O T O C R E D I T S

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