CIP SLIDE TRAINING SERIES IV-1

MAJOR POTATO DISEASES, NEMATODES, and INSECTS

INTERNATIONAL POTATO CENTER (CIP)

CIP SLIDE TRAINING SERIES

CIP Series IV, Potato Diseases and Pests, was produced by the Department of Training and Communications of the International Potato Center to assist in training potato program staff in developing countries.

This guidebook and accompanying slides introduce viewers to the major diseases, nematodes, and insect pests affecting the potato.

The information in this slide set is divided into seven sections: bacterial diseases, fungus diseases, virus diseases, mycoplasma diseases, adverse environmental diseases, nematode pests, and insect and mite pests.

The photographs highlight key symptoms of disease and pest damage. Not all symptoms are illustrated in these photographs because symptoms may vary with environmental conditions, variety, and pathogen variant.

These materials can be used alone or in conjunction with two related publications available from the International Potato Center (CIP): **Major Potato Diseases, Insects, and Nematodes**, a recently revised field guide containing 98 pages of detailed descriptions and colored illustrations of the information presented here; and **Compendium of Potato Diseases**, a detailed reference book.

For additional information on prevention and control techniques, viewers should consult with technical personnel in the specific country involved.

For more information on other CIP Slide Training Series, contact:

International Potato Center (CIP)
Department of Training and Communications
P.O. Box 5969
Lima, Peru

MAJOR POTATO DISEASES, NEMATODES, and INSECTS

INTERNATIONAL POTATO CENTER (CIP)

1983

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USE CHEMICALS SAFELY

Agricultural chemicals are potentially harmful to man and the environment. Use chemicals with care. Apply according to the manufacturer's directions. Consult your local agricultural authority for specific details on use and restrictions.

2

Major Potato Diseases, Nematodes, and Insects

1

Major Potato Diseases, Nematodes, and Insects

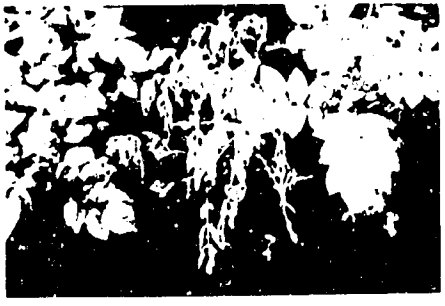
The potato is attacked by many different diseases, nematodes, insects, and mites which impair its quality and productivity. This slide set examines some of these major disease and pest problems.

2

Bacterial Diseases

BACTERIAL DISEASES

3



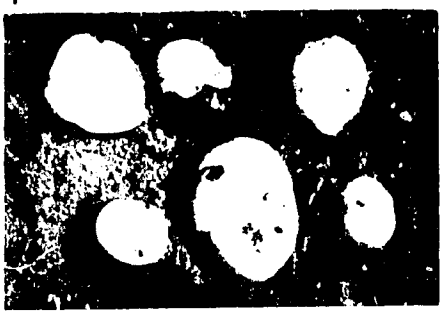
Bacterial Wilt
(*Pseudomonas solanacearum*)

Bacterial wilt or brown rot is the most serious bacterial disease affecting potatoes in warm regions of the world.

Symptoms include wilted and stunted foliage. Initially, only one

side of a leaf or a single branch wilts. Later, severe wilt develops with the foliage turning yellow and the plant eventually dying. Dark, narrow, vascular strands also appear on young potato stems.

4



Infected tubers usually are distinguished by a gray to brown bacterial slime that oozes from the eyes or stolon end of tubers and from the vascular ring of cut tubers. However, not all tubers from infected plants show symptoms. Certain strains produce no browning of the vascular ring.

Control: Crop rotation is the most effective control for potato race 3. Race 1, which affects many other crops and weeds, is more difficult to control.

Diseased seed causes the most severe bacterial wilt infection and spreads it to noninfected soil. The bacterium is also transmitted by water flowing along crop rows and by root-to-root contact.

5

Blackleg and Soft Rot
(*Erwinia* spp.)

Blackleg affects the stems of potato plants and may cause soft rot in tubers. Widely distributed, these diseases are especially harmful in humid climates.

Blackleg can occur at any stage of plant development when there is excess moisture. Black, slimy lesions progress up the stem from a soft-rotted mother tuber. Infected plants usually are stiff, their growth is stunted, and the foliage turns yellow.

6

Tubers produced from infected plants may have soft rot in the center. Soft rot begins in the stolon end and progresses inward.

7

When tuber surfaces are wet, soft rot bacteria may infect tubers through the lenticels, causing depressed circular areas. Tuber rot spreads rapidly when tubers are in storage or in the soil before harvest.

Control: Avoid planting tubers in wet soils and do not over-irrigate. Harvest tubers when they are mature. Handle gently to avoid tuber injury; soft rot often results from tuber injury. Do not leave tubers exposed to the sun. Dry tubers before storing and shipping them.

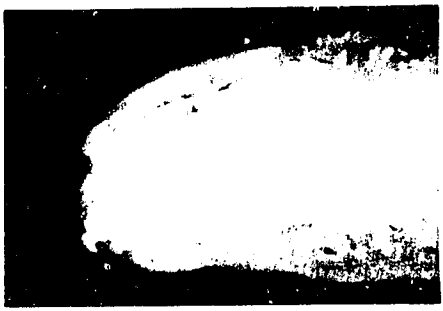
8

Ring Rot
(*Corynebacterium sepedonicum*)

Bacterial ring rot is a recurrent disease in temperate regions of the world. It is occasionally brought into tropical countries by infected seed from temperate regions.

Plant symptoms usually appear after mid-season. The lower leaves roll at the margins and wilt, turning pale yellow between the major veins. Eventually the plant dies.

9



The vascular ring of the tuber rots, turning gray, yellowish tan, or reddish brown. A bacterial ooze exudes from the vascular ring when it is squeezed.

10

When secondary organisms cause soft rot, the infection might be confused with brown rot or bacterial soft rot. However, there is no oozing around the eyes.

Control: Plant disease-free seed. Eliminate volunteers from previously infected crops. Do not plant cut tubers. Follow strict sanitation practices; disinfect bins, equipment, tools, and crates. Use new bags for clean seed.

11

Common Scab
(*Streptomyces scabies*)

Scab is a common tuber defect in most potato-growing regions of the world except where soils are very acid.

Scab is evident by the many types of lesions on the tubers. Lesions might be superficial or reticular, deep or pitted, or protuberant. They may join together, affecting the entire tuber surface.

Control: Maintain high levels of soil moisture while tubers are growing. Avoid successive plantings of potatoes with other scab-susceptible crops such as beets or crucifers with

fleshy roots. Maintain soil pH at 5 to 5.2. Avoid heavy lime applications but, when needed, apply dolomitic lime.

12

Fungus Diseases

FUNGUS DISEASES

13

Powdery Scab
(*Spongospora subterranea*)

Powdery scab develops mostly in cool, wet soils and might appear with black wart.

There are usually no aboveground symptoms of the disease. Signs of infection first appear on the tuber in the form of small, raised lesions. As host cells enlarge and divide, white, wartlike outgrowths appear on the tuber surface.

14

Later, these blister-like swellings darken and become open pustules, 2 to 10 mm in diameter. These pustules contain a mass of brown, powdery spores. Round lesions also appear on the tuber and are fringed by broken skin.

15

Galls up to 15 mm in diameter form on roots and will reduce plant vigor if they appear in large numbers. With newly formed galls, roots appear normal but later darken rapidly and disintegrate.

Control: Plant healthy tubers in well-drained soil that is disease-free. Long crop rotations might reduce the incidence of powdery scab.

16

Wart
(*Synchytrium endobioticum*)

Wart or black wart is widely distributed in temperate and tropical regions with cold, rainy climates. It can cause considerable yield loss. This disease is often associated with powdery scab.

Tumors up to several centimeters develop on the stem bases, stolon tips, and tuber eyes. Under wet conditions, tumors might also appear on stems and foliage.

Initially, tumors are white to brown, becoming black through decay. Later, they might rot due to secondary organisms. Abovegrcund warts are green, red, or purple.

Control: Plant resistant varieties. Long crop rotations of at least five years may reduce the incidence. The most effective way to limit disease spread is to stop shipping tubers, especially seed, from infected regions.

17

Late Blight
(*Phytophthora infestans*)

Although effective controls exist, late blight still remains the most serious fungus problem in many potato-producing regions.

Initially, small, pale to dark green lesions appear on the foliage. Later, these lesions turn brown when dry or black when wet. Under damp conditions, white, mildew-like sporulation also appears on the underside of leaves.

18

Pale yellow margins often form around leaf lesions. Stem and petiole lesions are black or brown. The entire plant may eventually die.

19

Rain may wash spores from the leaves and stems into the soil where spores infect the tubers. Infected tubers have a brownish discoloration on the surface. Cut tuber sections reveal brown, necrotic tissues blending with the healthy portions.

Control: The fungus usually survives in the plant tissue not in the soil. Thus, guard against the spread of disease from sources such as nearby infected potato and tomato fields, volunteer plants, or cull piles.

Resistant cultivars should be planted. Protective fungicides are effective when used in recommended dosages. Tuber infection can also be prevented by adequate hilling and by

spraying foliage during the growth period. Killing vines two weeks before harvest dries the sporangio on the leaves and rots the infected tubers.

20

Pink Rot
(*Phytophthora erythroseptica*)

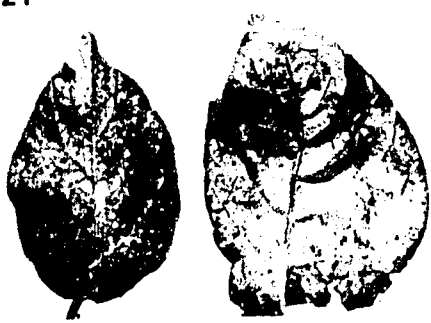
Pink rot is most severe in wet soils with temperatures above 20°C. It is generally not a major problem.

Infected tubers usually have dark brown to black tissue beneath the lenticels. Rotted tissue remains intact but is spongy.

Initially, plants may wilt from stem decay and leaf chlorosis. Lesions develop. Another striking characteristic is the color change that occurs when tubers are cut. Within 5 to 20 minutes, surfaces turn from a nearly normal cream color to pink and then finally black. Pink rot is accompanied by a faint odor similar to vinegar.

Control: Improve drainage because excessively wet soil conditions enhance this soil- and seed-borne disease. Plant disease-free tubers.

21



Powdery Mildew
(*Erysiphe cichoracearum*)

Powdery mildew is widely distributed on many host plants and may be severe on potatoes grown under arid conditions with high humidity. Although powdery mildew requires high humidity, it seldom develops on potatoes grown under sprinkler irrigation.

Initially, infected leaves are covered with white spore masses that resem-

ble soil or spray residue. Symptoms of severe infection resemble those of late blight. Leaves turn black and necrotic, and the plant eventually dies. Stems may also be infected.

Control: Use elemental sulfur dust or fungicide sprays. Crop losses seldom justify chemical control. A heavy rain will also stop the progress of the disease.

22

Early Blight
(*Alternaria solani*)

Although early blight or Alternaria blight is found worldwide, it is an important foliage disease of potatoes in only a few areas.

Tuber lesions are dark and recessed with dry, leathery flesh underneath. Tissue in advanced decay is often water-soaked and yellow to greenish yellow.

23

Brown, necrotic spots that are angular in shape first form on the lower leaves. Advanced lesions are marked by a series of concentric rings, giving the lesions a "bull's-eye" appearance. The formation of large leaf lesions is restricted by the larger veins. Lesions develop around blossom time, becoming more numerous as plants mature. As new lesions develop, they may join together, causing general yellowing, leaf drop, or early death.

Control: This disease occurs late in the growing season. Therefore, provide conditions for vigorous growth, especially with irrigation and fertilizer used for side-dressing. Organic fungicides sprayed on foliage reduce the spread of early blight.

24

White Mold
(*Sclerotinia sclerotiorum*)

White mold affects potatoes grown mainly in the cool tropics and temperate zones. It causes major damage when potatoes are rotated with susceptible vegetable crops such as beans, lettuce, and tomato.

Stem lesions covered by a cottony mycelial mat and sclerotia develop at the soil line or near leaf axils. Irregular-shaped leaf lesions usually appear at the base of leaflets.

The pith of the stems is destroyed and the hollow fills in with white mycelium, which later forms hard, black sclerotia up to a centimeter long. The tops wilt, and stalks split or break at the soil surface.

25

Tubers near the soil surface shrink and become black and watery. Cavities later fill with mycelia and sclerotia. Sclerotia germinate forming mycelial mats or small and fleshy, cup-shaped mushrooms. They are sources of air-borne spores that infect leaves and stems of many dicotyledonous crops and weeds.

Control: Destroy long-lived sclerotia by flooding fields between crops. Rotate potatoes with nonsusceptible crops and destroy infected plants.

26

Stem Rot
(*Sclerotium rolfsii*)

Stem rot, southern blight, or Sclerotium rot occurs worldwide, attacking a wide range of plants. It is only a problem for potatoes grown under hot, moist conditions.

Initially, daytime wilting and yellowing occur when brownish lesions girdle the stem base just beneath the soil surface. A white mycelium, often in fan-like mats, grows on the stems, tubers, or soil. This usually produces small, white sclerotia that later turn brown.

27

Tubers might rot in the field before harvest or while in storage or in transit. Rot begins as a semi-firm decay, which is often accelerated later by secondary invaders. Seed tubers might rot before plants emerge.

Control: Sclerotia are difficult to control because they are long-lived, and many crops are susceptible. Remove affected plants and crop residues, and either burn or bury them. The pathogen is highly aerobic; plow deeply and rotate with paddy rice. Harvest during dry weather.

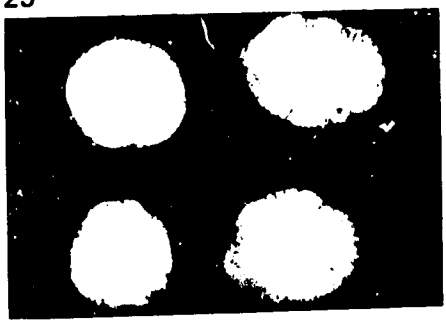
28

Black Rot
(*Rosellinia* sp.)

Black rot may cause severe potato yield losses in high tropical altitudes where moist soils are rich in organic matter, such as in recently cleared land.

Diseased plants are stunted and wilted. Roots, tubers, and stolons develop a black rot and are partially covered by matted strands of grayish-white mycelium.

29



When cut, blackened tubers show a band of striate projections penetrating into the flesh. Single plants or groups of plants may be infected in the field. Tubers frequently rot before harvest.

Control: Remove or burn brush and trees when clearing land. Rotate potatoes with nonsusceptible crops.

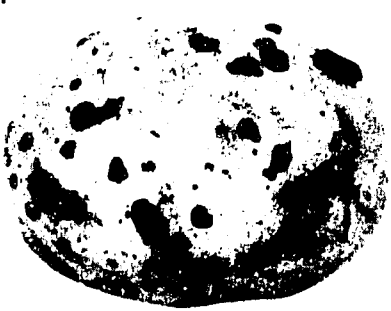
30

Stem Canker and Black Scurf
(*Rhizoctonia solani*)

The fungus that causes stem canker and black scurf is present in nearly all soils. It has many hosts, survives in plant debris, is easily disseminated on tubers, and grows in a wide range of temperatures. It damages emerging sprouts when conditions, such as cold and wet soil, do not favor rapid emergence.

Symptoms vary. Lesions on sprout tips delay or halt emergence. Brown cankers appear on the stems or stolons at or below the soil line. Cankers may girdle the stems which results in aerial tubers, plant wilt, or death.

31



Hard, superficial, irregular brown or black sclerotia form on the tuber surface. A harmless, white mycelial mat may develop on the stem base.

Control: Sclerotia are long-lived in the soil. Long rotations with cereals and grasses may reduce the incidence. Plant well-sprouted tubers in shallow beds to reduce exposure time in the soil. If the soil is not heavily infected, soil fungicides and seed tuber treatment help reduce seed-borne inoculum.

32

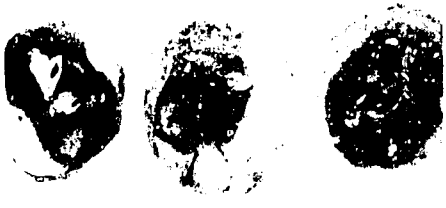
Gangrene
(*Phoma exigua* ssp. *foveata* and *P. exigua* ssp. *exigua*)

Gangrene or Phoma rot creates serious storage problems in cool and wet climates in temperate zones. Infection most often follows tuber injury, and rot is particularly severe in cold storage.

Small, dark depressions form in the tuber skin. These depressions may enlarge to form deep, dark brown or purplish cavities with clearly defined margins.

Control: Destroy haulm early and carefully harvest and handle well-ripened tubers. Store tubers initially in high humidity at about 18°C for ten days to heal tuber wounds. Disinfect tubers with fungicide dips, fumigation, or mist sprays. Plant disease-free seed.

33



Fusarium Dry Rot and Wilt
(*Fusarium* spp.)

Different species of *Fusarium* cause different problems. Warm temperatures favor this disease. *Fusarium* dry rots are found on potatoes worldwide.

Fusarium dry rot is one of the most serious problems in storage. Tubers initially show dark, slightly recessed lesions. Later, these lesions expand with internal rot and leave cavities that contain different colored mycelia, depending on the species. The margin of rot is clearly identified. Rotten tubers eventually shrivel and harden.

34

Fusarium wilt fungi are soil-borne. Plant symptoms include yellowing of lower leaves, chlorotic mottle of upper leaves, and subsequent wilting. The vascular tissue of the stems and tubers becomes discolored. Warm weather enhances wilt.

Control: Use disease-free seed, water properly, and rotate crops.

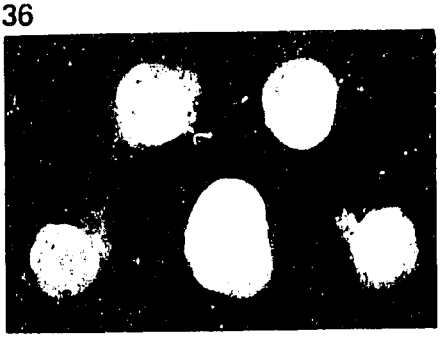
35

Verticillium Wilt
(*Verticillium albo-atrum* and *V. dahliae*)

Verticillium wilt may be a serious problem in tropical and subtropical regions and in irrigated deserts where water shortages may be severe. It can also be severe in cooler regions during prolonged warm, dry weather.

This disease is characterized by leaf yellowing. Single stems or leaves on one side of the stem wilt first. Later, the entire plant wilts and the vascular system of the lower stem turns light brown. Frequently plants yellow and mature early without pronounced wilting.

36



The vascular ring of tubers usually develops a light brown discoloration that may extend from a few millimeters to more than halfway through the tuber. Larger tubers often have a light tan discoloration around the eyes.

Control: Rotate crops with non-susceptible plants, cereals, grasses, or legumes. Resistant or tolerant potato cultivars should be planted. Remove soil-borne inoculum by disinfecting seed tubers with fungicides. Irrigate to prevent water stress.

37

Thecaphora Smut
(*Thecaphora* [*Angiosorus*] *solani*)

Potato smut, which is restricted to the tropical regions of the Americas, occurs in cool highlands and irrigated coastal deserts.

There are usually no aboveground symptoms. Galls resembling tubers appear on the stems and stolons. These galls contain small cavities filled with brown to black spores.

Control: Resistant or tolerant potato cultivars should be planted. Crop rotation may be beneficial, although the disease persists in fields for years. Follow strict quarantine procedures to prevent spreading the disease. Chemicals to treat the soil are available.

38

Virus Diseases

VIRUS DISEASES

39

Potato Leafroll Virus
(PLRV)

Potato leafroll virus (PLRV) is one of the most serious virus diseases affecting potatoes. Transmitted by aphids, it is common wherever potatoes are grown. PLRV can reduce yields dramatically.

The primary symptoms of PLRV appear in the apical leaves which tend to roll and stand upright.

Leaves generally turn pale yellow but may be tinged with purple, pink, or red, depending on the cultivar.

40

Secondary symptoms are evident when the infected tubers produce plants. These plants are usually stunted and grow upright. The lower leaves are rolled and the upper leaves may be slightly pale.

41

Subspecies *andigena* shows marginal and interveinal chlorosis, especially in the upper leaves. Plants grow upright and show severe stunting. Lower leaves are rarely rolled.

Control: Select healthy plants and rogue diseased plants during seed production. Systemic insecticides decrease the spread of disease by virus-carrying aphids within a crop, but will not completely prevent infection by viruliferous aphids from nearby fields.

42

Potato Viruses Y and A (PVY and PVA)

Potato virus Y (PVY) is the second most serious potato virus. It is perpetuated through infected tubers and transmitted by aphids. Yield losses are usually high. Potato virus A (PVA) is similar to PVY.

The foliage of infected plants wrinkles and bunches. It also becomes twisted, with the leaflet margins turning down.

43

Stunted plants and necrotic spotting on leaves are usually a result of primary infection.

44

Leaf necrosis, including vein necrosis, and stem streak are the most common symptoms. Less sensitive cultivars may show mild mosaic.

Control: Select healthy clones and rogue diseased plants to control PVY and PVA. Plant early and use resistant cultivars. Plan to harvest before heavy aphid flights.

45

Mosaics
(PVX, PVY, PVA, PVM, PVS)

Mosaic symptoms in potato leaves may be caused by several individual viruses alone or in combination. Potato virus X (PVX) is perpetuated through infected tubers and transmitted by contact. Some strains of PVS and PVM are transmitted by aphids. Mosaic symptoms include mild to severe crinkling and necrotic spotting. Leaves may also drop from the plant.

Control: Select healthy clones during multiplication of seed stock. Roguing is useful when obvious symptoms develop.

46

Andean Potato Mottle Virus and Andean Potato Latent Virus (APMV and APLV)

Andean potato mottle virus (APMV) and Andean potato latent virus (APLV) are common in the Andean region of South America. They are readily transmitted by contact and, to an unknown extent, by beetle vectors.

Primary symptoms include mottle, top necrosis, leaf deformation, and stunting or delayed emergence. The potato flea beetle, *Epitrix* sp., transmits APLV. APMV is transmitted by *Diabrotica* leaf beetles.

Control: Clonal selection, roguing, and hygienic cultivation practices in the field help control APLV.

47

Potato Mop-Top Virus (PMTV)

Potato mop-top virus (PMTV) occurs in areas with cool, damp conditions which favor development of its fungus vector, *Spongospora subterranea*. In sensitive cultivars, yields may be substantially reduced and tubers unfit for sale.

Primary symptoms develop in the tubers which are directly infected from the soil. Symptoms include brown rings on the tuber surface which are associated with necrotic arcs in the tuber flesh. The source of infection is a powdery-scab lesion in the center of the virus ring. Severe secondary symptoms include malformation, gross cracking, fine superficial cracking, surface blotching, and necrotic arcs on the stolon.

48

There are three types of secondary vine symptoms: bright yellow (aucuba) markings especially on lower leaves; pale V-shapes (chevrons) on upper leaves; and stunted stems (mop-top). The bright yellow markings consist of blotches, rings, and diagnostic V-shapes. Usually a plant has normal and infected stems.

Control: Treat infected soil with calomel, sulphur, or zinc oxide to inhibit infection in a healthy crop. Rogue the cultivars that exhibit strong symptoms.

49

Tobacco Rattle Virus (TRV)

Tobacco rattle virus (TRV) occurs mainly in light or sandy soils which favor its vector nematodes, *Trichodorus* spp. and *Paratrichodorus* spp. Heavy crop losses may occur in sensitive cultivars with severe tuber symptoms.

Tuber symptoms develop from virus-transmitting nematodes that feed directly on tubers. Necrotic arcs or spots in the tuber flesh are often visible. Secondary tuber symptoms are malformation and internal flecking.

50

Symptoms on the foliage result from infection in the emerging stems or from infected tubers. Foliage symptoms include mottle, leaf deformation, necrotic spotting, yellow spots or small rings, and stunting. Normally, only a few stems of a plant are affected.

Control: TRV is most important in ware potatoes, not seed tubers. Apply nematicides to the soil to help prevent infection.

51

Calico and Aucuba Diseases (AMV, PAMV, TRSV, TBRV)

The importance of calico and aucuba diseases, which usually occur under cool conditions, depends on the virus strain and potato cultivar.

Symptoms include bright yellow spots, blotches, mosaic and top necrosis, and yellowing around the veins. Sometimes leaflets are completely yellow. Similar symptoms are caused by alfalfa mosaic (AMV), potato aucuba mosaic (PAMV), tobacco ringspot (TRSV), and tomato black ring (TBRV).

Control: Rogue diseased plants during seed production. Apply chemicals to control aphid and nematode vectors.

52

Mycoplasma Diseases

MYCOPLASMA DISEASES

53

Purple Top Wilt (Aster yellows and other mycoplasma diseases)

The "yellow" types of diseases are caused by mycoplasma organisms, which are neither viruses nor bacteria. They severely reduce yield, as well as tuber sprouting and quality. They are transmitted by leafhoppers.

Shoots or aerial tubers develop in the leaf axils.

54

Plants are often stunted and may die prematurely. Apical leaves may roll and turn yellow or purple. Tubers from infected plants either do not sprout or have only thin "hair" sprouts. Tubers are often small, flaccid, and malformed.

Control: Insecticide sprays and certain cultural practices help control leafhopper vectors which transmit purple top wilt.

Symptoms will disappear when plants are treated with tetracyclines but appear again when treatment is discontinued.

55

Adverse Environmental Diseases

ADVERSE ENVIRONMENTAL DISEASES

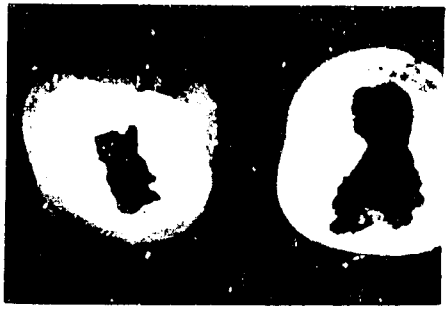
Oxygen Deficiency

The underground parts of the potato have high oxygen requirements during development. When oxygen is reduced, tuber development is impaired and stolens are abnormal.

Oxygen deficiency can occur whenever temperatures are too low or too high. Injury can occur both in the field and in storage, particularly if air movement around tubers is restricted.

Two diseases associated with oxygen deficiency are black heart and internal heat necrosis.

56



Black heart. The center of the tuber blackens after acute oxygen deficiency, which is caused by low temperatures in confined storage or high temperatures in field soil. Discolored tissue becomes soft and inky when exposed to room temperatures. The affected tubers will eventually rot.

57

Internal heat necrosis. Internal heat necrosis is a field problem associated with high temperature injury. It is often severe in sandy or muck soils that are exposed to the sun after an early vine death or a delayed harvest. The centers of the tubers turn from light tan to reddish brown to black, depending on the severity of the injury.

Control: Tubers with symptoms of oxygen deficiency should not be used as seed. Avoid high temperatures in field soil by harvesting promptly after the vines have died. Maintain cold storage temperatures of 4°C or slightly higher. Improve aeration in storage.

58

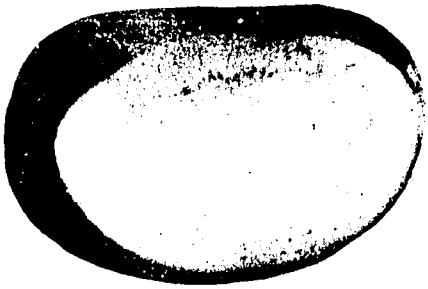
Low Temperature Injury

Tubers might freeze in the ground before harvest or be injured later by low temperatures in storage. When frozen tubers thaw, they become soft and spongy, and water leaks from the wounds and eyes. Tissue turns from off-white to pink and eventually to brown or black. Frozen tissue breaks down in a soft watery rot, leaving a chalky residue as the water evaporates.

59

If tubers are stored for a long time at low temperatures slightly above freezing, they retain sugar which turns potatoes a dark color when fried. Other symptoms include smoky gray to black tissue, a gray to black vascular ring, and

60



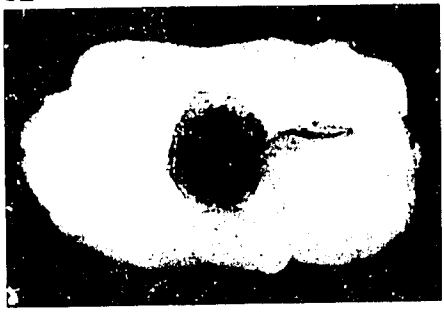
... net necrosis. Affected potatoes stored at warmer temperatures often soft rot.

61

Frosted leaves first turn brown and then black when wet. Leaf primordia may be injured, although low temperatures do not actually freeze tissue. Leaves forming after such injury may be distorted with yellowish spots or holes.

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

62



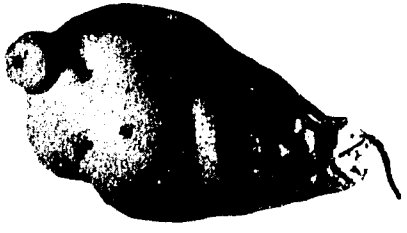
Tuber Growth Abnormalities

Hollow heart. Excessively rapid tuber growth can result in hollow heart or other types of internal cavities, external tuber surface splitting, or growth cracks. These defects are apparent only when the tuber is cut in half.

63

Second growth. Second growth is usually associated with such adverse environmental conditions as high field temperatures and drought. After their initial expansion, when environmental conditions improve, tubers may begin a second growth that is characterized by knobbiness and irregular shapes.

64



Jelly end rot. When tubers resume growth after an inactive period, carbohydrates frequently translocate from the basal part to another part of the same tuber. This leaves a wet, soft mass called jelly end rot.

Control: Close and regular spacing of plants prevents tubers from growing excessively large and also promotes uniform stands. Regulate the water supply to provide uniform growing conditions, especially during early tuber development.

65

Tuber Cracking and Bruising

Cracking and bruising can occur at harvest when tubers are dropped or partially crushed. It is severe when turgid tubers from cold soil are harvested.

Control: Handle tubers carefully. The soil should be warm before harvesting.

66

Chemical Injury

Agricultural chemicals. Improperly applied chemicals can cause deformed plants, leaf distortion...

67

... chlorosis, necrosis, and stunting in the year of application. New tubers might be distorted with necrotic tissue.

Control: Chemical injury from commercial fertilizers, insecticides, and fungicides can be avoided by applying them according to the manufacturer's directions.

68

Air pollution injuries. Photochemical oxidants, such as ozone, cause early maturity and plant death. Lower leaves yellow and die prematurely. Sulfur oxides typically cause chlorosis and bleaching or burning of the leaves between major veins before killing the entire leaf. Symptoms of air pollution injury resemble those of senescence and poor nutrition.

Control: Injuries due to air pollution are difficult to diagnose and

control because the pollution may be widespread and its source difficult to determine.

69

Nonvirus Leafroll

Potato leaves may roll upward for reasons other than virus leafroll. Genetic factors as well as certain environmental conditions—intense light, long days, and nutrient imbalance in the soil—may cause the leaves to roll.

Plant feeding by the potato aphid, *Macrosiphum euphorbiae*, also can result in leafroll in the absence of a leafroll virus. Once aphid feeding stops, new growth is normal.

Control: Nonvirus leafroll is not infectious and infected plants usually yield well. Proper diagnosis of leafrolling is especially important in seed programs.

70

Nutrient Imbalance

Potatoes grow best in soils of pH 5.0 to 7.0. A deficiency or excess of a particular nutrient is influenced by such factors as soil pH and how a nutrient interacts with colloids or chemicals in the soil. Potato plants may suffer from imbalances in nutrients such as nitrogen, phosphorus, or potassium.

Nitrogen deficiency. Nitrogen is translocated to upper leaves from the lower leaves, which are most severely affected. First the leaves and then the entire plant turns yellow. Deficient plants generally are chlorotic and erect with slow growth. The severity of plant response depends on the level of nitrogen deficiency.

71

Phosphorus deficiency. Plants with phosphorus deficiency are small, spindly, and somewhat rigid with crinkled or cup-shaped leaves. They are abnormally dark and slow to mature. Plants with phosphorus deficiencies have reduced yields. Cut tubers may reveal rusty brown necrotic flecks, similar to internal heat necrosis.

72

Potassium deficiency. Potassium deficiency is common in light soils that are easily leached. An early symptom is unusually dark green, bluish green, or glossy foliage. Older leaves become bronzed and necrotic with early senescence.

Control: To avoid nutrient imbalances, make a soil analysis before applying chemical fertilizers.

73

Nematode Pests

NEMATODE PESTS

74

Cyst Nematodes
(*Globodera pallida* and
G. rostochiensis)

In some temperate potato-growing areas, potato cyst nematodes or golden nematodes can cause considerable yield reductions. In the tropics, these soil pests usually are found at elevations above 2000 meters.

Female cyst nematodes are tiny, measuring between 0.5 to 1.0 mm in diameter. They are found on potato roots and tubers. Initially, the females are white or yellow. Later, when these females die, their bodies turn brown and become cysts which contain eggs. These eggs remain viable for many years. The presence of potato root exudates stimulates eggs to hatch. Large populations of nematodes cause stunting and early senescence in plants.

Control: Cyst nematodes can be partially controlled with 7- to 8-year crop rotations or with soil fumigation. Some potato cultivars have resistance to certain nematode races.

75

Root-Knot Nematodes
(*Meloidogyne* spp.)

Although root-knot nematodes are distributed worldwide, they do the greatest damage in temperate and hot regions.

Aboveground symptoms of root-knot nematodes are similar to those produced by any type of root damage—stunting, yellowing, and wilting during hot periods of the day. Infected roots have knots or galls of varying sizes and shapes.

76

Infected tubers might also be galled or deformed, or show internal symptoms of nematode feeding.

Nematodes may interact with other pathogens to cause disease complexes.

Control: Treat the soil with nematicides or fumigants, and rotate potato crops with cereals. Long, fallow periods will also reduce nematode populations.

77

False Root-Knot Nematode
(*Nacobbus aberrans*)

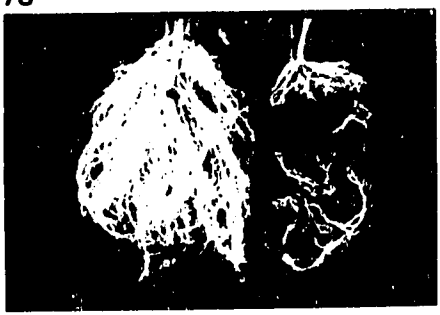
The false root-knot nematode is becoming a major problem as it spreads throughout potato-producing areas.

Infected plants display symptoms typical of any root damage—stunting, yellowing, and wilting during hot periods of the day. Galls form in a bead-like fashion on the roots.

Nematodes also attack tubers by penetrating under the skin to a depth of 1 to 2 mm. Infected tubers, however, show no outward symptoms of nematode infection. Therefore, be careful not to use these infected tubers for seed as they can spread nematodes to noninfected soil.

Control: Rotate crops with cereals to reduce nematode populations. Fields should lie fallow periodically. Treat the soil with fumigants and nematicides.

78



Lesion Nematodes
(*Pratylenchus* spp.)

Lesion nematodes are found throughout the world and can reduce crop yields by one-third or more.

High populations of lesion nematodes reduce plant vigor. Plants turn yellow and eventually cease to grow. Lesion nematodes also cause dark brown necrotic lesions in the cortical root tissue.

79

On tubers, lesion nematodes produce wartlike protuberances, pimples, and lesions, which reduce the market value of tubers. When used as seed, infected tubers will spread nematodes to the noninfected soil.

Lesion nematodes can interact with other pathogens to cause disease complexes.

Control: Prevent tuber damage by harvesting early and storing tubers in cool conditions. Do not use infected tubers as seed. Treating seed pieces with nematicides or with hot water at 50° C for 45 to 60 minutes can help control nematodes.

80

Insect and Mite Pests

INSECT AND MITE PESTS

81

Green Peach Aphid and Others
(*Myzus persicae* and other aphidae)

Green or flesh-colored aphids are found worldwide. They are 1 to 2 mm long, have soft bodies, and may be winged or wingless. Aphids transmit diseases by moving and feeding among plants in a field and among tuber sprouts in storage. They also damage plants by sucking sap from the leaves and stems.

82

Symptoms of aphid damage include wrinkling, cupping, and downward curling of young leaves. Older leaves wilt, turn yellow, and die prematurely.

Aphids usually are found on the underside of leaves, although occasionally they disappear, leaving a grayish-white skin cast on the leaf surface.

Control: Spray systemic, organo-phosphorus insecticides on foliage or use granular, systemic carbamates at planting time. But, use aphicides carefully as they also kill beneficial aphidian predators and parasites. Monitor aphid populations before applying insecticides.

83

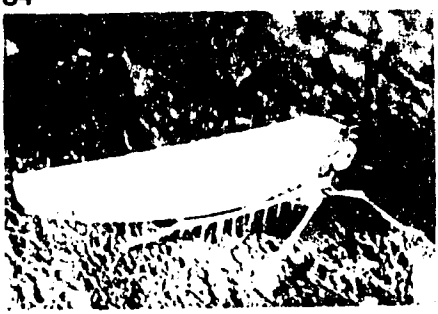
Thrips
(*Frankliniella* spp.)

Thrips are found in tropical and temperate climates. Adults are black and 2 mm long. Both adults and nymphs live on the undersides of potato leaves, feeding on plant juices. This feeding causes a silvery flecking on the leaves. With severe

damage, leaves become completely dry and fall from the plant. The entire plant dies.

Control: Avoid drought as thrips propagate under dry conditions. Insecticides are also effective. Use granular, systemic carbamates at planting time. Later, spray systemic organophosphate insecticides.

84



Leafhoppers
(*Empoasca* spp. and other genera)

Leafhoppers are pale green and approximately 3 mm long. They are found worldwide. Nymphs and adults suck sap from the undersides of leaves. With "hopper burn," leaf margins curl downward, turn yellow and then brown. Plants die prematurely.

Control: Plant resistant cultivars. Reduce early season infestation by applying granular, systemic carbamates to the soil at planting time. Later, when leafhopper populations increase, spray systemic organophosphates on the foliage.

85

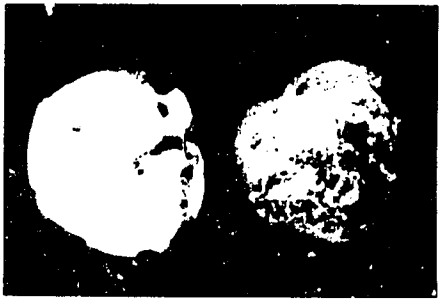
Potato Tuber Moth
(*Phthorimaea operculella* and *Scrobipalpopsis solanivora*)

Several species of the potato tuber moth cause damage when the insects are in the larval stage. The adult potato tuber moth is grayish brown with a wingspan of approximately 15 mm. Larvae are about 10 mm long.

86

Larvae of *P. operculella*, the most important potato tuber moth, are found in warm regions of the world. They tunnel into foliage...

87



... stems, and tubers. Eventually there is a loss of leaf tissue, the growing points die, and the stems weaken or break.

Control: Rotate crops, use clean seed tubers, plant tubers deep, hill well, irrigate, control weeds, and keep fields and storage areas clean. Protect stored seed and consumer potatoes by applying a synthetic pyrethroid insecticide that is not harmful to humans.

88

Cutworms
(*Agrotis* spp.)

These nocturnally active moths are found throughout the world. Damage is caused by larvae. When disturbed, they characteristically curl up.

Cutworms exhibit different feeding habits. The armyworm feeds on the foliage of potato plants, as shown here. The black cutworm, on the other hand, consumes or "cuts" the stems near the soil surface. And the greasy cutworm, one of the subterraneans, "gnaws" cavities into tubers, especially those near the soil surface.

Control: Avoid planting potatoes after growing grasses or cereals that are especially sensitive to cutworms. Eliminate susceptible weeds, make good ridges, and mix insecticides into the soil before planting.

Most cutworms can also be controlled with baits consisting of carbamates and organophosphates mixed with wheat bran, molasses, and water. Place baits at the base of plant stems shortly before dusk. Baits are more attractive to cutworms at that time of day when the weather is moist and fresh.

89

Potato Flea Beetle
(*Epitrix* spp.)

Potato flea beetles are widespread. Adults, approximately 2 to 3 mm long, produce holes about 1 mm in diameter in leaves. Eventually the leaves dry up and die.

90

Larvae of the potato flea beetle also feed on roots and tubers, creating a fine network of tunnels.

Control: Keep fields clean and eliminate weeds which will reduce the flea beetle's food and shelter, as well as its overwintering sites. Flea beetles and aphids can also be controlled by applying granular systemic carbamates to the soil. Later, spray organophosphates on foliage.

91

Blister Beetles
(*Epicauta* spp.)

Adult blister beetles, 10 to 15 mm long, damage leaves of several important crops. After the adults feed, only leaf midribs remain.

Control: Use contact organochlorine or organophosphate insecticides.

92

Leaf Beetles
(*Diabrotica* spp.)

Leaf beetles are 6 to 8 mm long. They attack a wide variety of plants worldwide. They produce small holes in leaves similar to damage caused by adult flea beetles. Most damage occurs in wet seasons.

Control: Use granular systemic carbamates at planting time for early season control. Later, spray foliage with systemic organophosphates.

93

Andean Weevils
(*Premnotrypes* spp.)

Andean weevils are found in the Andes mountains of South America. Adults, 8 to 10 mm long, feed on leaf margins.

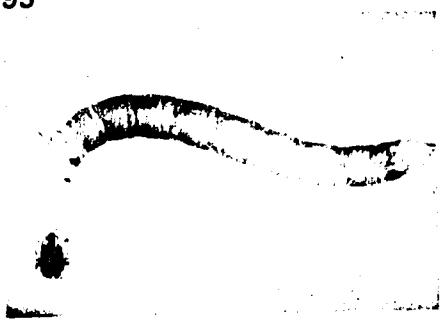
94

Larvae, 10 to 12 mm long, produce tunnels in potato tubers, making them unfit for human consumption or seed.

Control: Thoroughly cultivate prior to planting and eliminate weed hosts. Apply systemic, granular carbamates to the soil for early season control.

Later, when adult damage appears, spray organophosphate insecticides.

95



Wireworms
(*Agriotes* spp.)

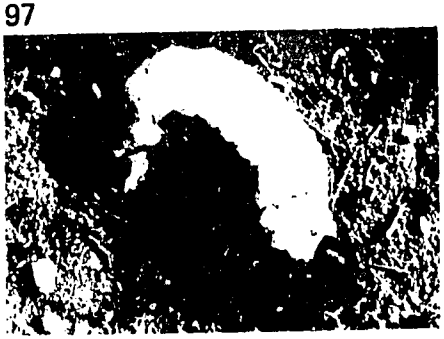
Wireworms are usually found in temperate climates and occasionally in the tropics. Mature larvae are approximately 25 mm long.

96

Wireworm larvae feed on tubers and roots, producing cavities.

Control: Rotate with crops that require frequent cultivation and use granular systemic insecticides at planting time.

97

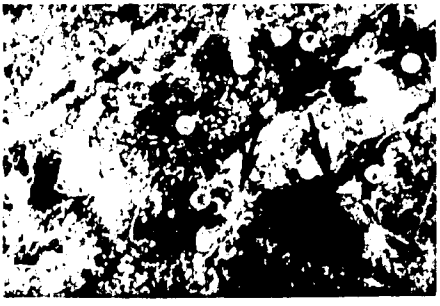


White Grubs
(*Phyllophaga* spp. and other *Scarabaeids*)

White grubs are larvae of scarabaeid beetles. They are found worldwide in all types of soil. Fully grown larvae, approximately 5 cm long, damage roots, stems, and tubers.

Control: Avoid planting potatoes in old pasture land. Rotate potatoes with legumes. Plow deeply to bring grubs to the surface where they will be destroyed by birds, sun, or frost. Apply carbamate or organophosphate insecticides at planting time.

98



Mites
(*Tetranychus* sp.)

Mites occur worldwide and damage many crops. They develop on potatoes during warm weather. Mites are microscopic, and can be seen at magnifications of more than 15X.

99

Early mite damage appears as brown spots on the undersides of leaves. Leaves become shiny and bronzed. Young leaves might be distorted or fail to grow, and growing tips might die.

Control: When possible, avoid growing potatoes in warm weather if mites are a problem. Otherwise, spray miticides according to local recommendations.

100

Produced by

INTERNATIONAL POTATO CENTER (CIP)
P.O. Box 5969, Lima, Peru

For more information on diseases and pests affecting the potato, contact the International Potato Center (CIP), P.O. Box 5969, Lima, Peru.