20 Ginseng

FUNGAL DISEASES

▶ 20.1 Alternaria blight *Figs. 20.1 a-c; 20.3a*

Alternaria panax Whetzel in Whetzel & Rosenb.

Alternaria stem and leaf blight was first described from New York State in 1904 and has been known in Ontario since that time. This disease now affects ginseng production throughout North America and Asia. It can produce severe epidemics when not controlled with fungicidal sprays. Alternaria blight may kill young plants directly or limit the yield of harvested roots by causing premature defoliation. *Alternaria panax* has been reported to cause disease in several members of the Araliaceae, most of which are tropical foliage plants.

Symptoms Stem infection results in the production of elongate, reddish to dark brown lesions *(20.1b).* Any portion of the stem may be affected as well as the petioles and peduncles. The lesions often appear to originate where the stem is in contact with straw mulch. Leaves collapse downwards and turn yellow to reddish-brown. These symptoms are similar to those of phytophthora root rot. Leaves are killed when the lesions girdle the stem. In seedlings, the entire plant collapses, resulting in a damped-off appearance *(20.3a).* The fungus sporulates on the surface of the lesions, producing conidia in chains or as solitary spores, giving the lesions a velvety-brown appearance.

The foliar symptoms of alternaria blight are distinguished from botrytis blight by the presence of a yellowish border *(20.1a)* and the absence of a gray surface mold. However, microscopic examination of the lesions may be required to differentiate between these two diseases. Stem symptoms are distinguished from *Rhizoctonia* damage by the velvety brown surface sporulation and the occurrence of lesions on the upper portions of the stem. Characteristic, club-shaped *Alternaria* conidia may be seen on the lesion surface at low magnifications.

When foliage is infected, the pathogen causes rapidly enlarging, circular, water-soaked spots, which may later dry, turn brown and have a target-board appearance with a dark yellow-brown margin. Lesions may appear anywhere on the surface of the leaves. The interior portions of the lesions may eventually fall out to produce a shot-hole effect. Plants may be defoliated by the rapidly spreading foliar infection.

Causal agent *Alternaria panax* produces conidia on the surface of infected plant tissues. It can overwinter on residues from the previous crop. Conidia *(20.1c)* are large, beaked, 150 to 160 by 12 to 20 µm, with 9 to 11 transverse septa in the main body of the spore. The central four to five segments may possess one to two longitudinal septa. Conidiophores are geniculate. Much smaller (less than 30% of the described size), often swollen-appearing conidia are frequently encountered on older lesions or in artificial culture. Production of conidia in culture is erratic and only small spores in chains are formed. The fungus grows well on standard media, such as potato-dextrose or V-8 juice agar, and can be isolated from lesion margins or directly from conidia that have been dislodged from the lesion surface.

Disease cycle Alternaria blight is first seen on the leaves in early to mid summer, especially in warm (20 to 25°C), rainy or humid weather. Stem cankers appear earlier in the spring before the foliar lesions are formed. All ages of plants are affected, but stem lesions predominate on the youngest plants. *Alternaria panax* is also suspected of causing dark brown to black root lesions and the abortion of developing berries, but critical work remains to be done on these aspects of the disease. Often, plants affected by alternaria blight occur in patches in the garden, suggesting spread from an initial focus. Plants defoliated one year may re-emerge the following year, but the yield of roots is reduced.

The pathogen is thought to overwinter as conidia or mycelia on the straw mulch and infested crop residue from the previous year. Plant-to-plant spread is by air-borne conidia. Relatively little is known about the infection process on ginseng.

Management

Cultural practices — Growers should remove affected plants from the garden, if practical. The movement of machinery or workers from infested to non- infested gardens should be restricted. Excessive rates of nitrogen should be avoided to limit canopy growth and improve air circulation and the penetration of sprays into the plots.

Chemical control — Registered fungicides are available.

Selected references

David, J.C. 1988. *Alternaria panax.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 955. C.A.B. Internat. Mycol. Inst., Kew, Surrey, England. 2 pp.

Wang, S., H. Yu, and X. Chen. 1981. On the black spot (*Alternaria panax* Whetz.) of Sanqi *(Panax notoginseng* (Burk.) F.H. Chen). *Acta Phytopathol. Sinica* 11:45-52.

Yu, S.H., S. Nishimura and T. Hirosawa. 1984. Morphology and pathogenicity of *Alternaria panax* isolated from ginseng in Japan and Korea. *Ann. Phytopathol. Soc. Jpn.* 50:313-321.

(Original by R.A. Brammall)

▶ 20.2 Botrytis blight *Fig. 20.2*

Botrytis cinerea Pers.:Fr.
(teleomorph *Botryotinia fuckeliana* (de Bary) Whetzel)
(syn. *Sclerotinia fuckeliana* (de Bary) Fuckel)

Botrytis blight is common in southwestern Ontario and is one of the most important foliar diseases currently affecting the crop. Botrytis blight also occurs in British Columbia, but the arid growing conditions of central British Columbia are less favorable for disease development than those in southern Ontario. The pathogen affects the leaves, flowers and fruit, leading to defoliation of the plants and poor seed set. Although the disease is easy to diagnose by signs, growers often mistake the foliar lesions for those of alternaria blight. *Botrytis cinerea* has a wide host range that includes many vegetable crops (see Lettuce, gray mold, 11.10).

Symptoms Botrytis blight of the foliage is characterized by rapidly enlarging, water-soaked lesions. Infection often starts at the leaf tip and spreads back along the midrib, giving the lesion a V-shape. Lesions may be found anywhere on the surface of the leaf (20.2). They show a target-board appearance, similar to those of alternaria blight. Affected leaves may turn reddish to brown prematurely. The fungus often sporulates on the rotted tissues, producing a characteristic fuzzy gray mold.

Infection of the developing flowers causes them to abort. Aborted flowers desiccate and the persistent pedicels turn reddish to brown. Fruit development over the umbellate inflorescence is uneven. When immature green berries become infected, they turn brown and often show signs of *Botrytis* sporulating over the surface. Mature red fruit may become covered by a dense gray fungal growth.

Causal agent *Botrytis cinerea* (see Lettuce, gray mold, 11.10) can be isolated from margins of lesions or from conidia removed from the surface of rotting tissue. It grows well on common fungal growth media, such as potato-dextrose or V-8 agar.

Disease cycle Plants may be infected at any stage of their development and at any time throughout the growing season. The disease is favored by temperatures lower than 20°C. Symptomatic plants first appear near garden edges, especially if these plants have been subjected to sand-blasting injury, a common occurrence in southwestern Ontario. Abundant conidia are formed on the surface of rotted tissues and are aerially dispersed to produce new infections. Spread through the garden is rapid, especially when a dense canopy is present, usually in gardens three years of age and older. Lesions are usually first seen on the uppermost leaves, but a careful examination often reveals the disease to be well developed on the shaded understorey leaves. Infected leaves collapse and drape over those lower in the canopy, thus initiating new infections at points of contact. The fungus overwinters as sclerotia within infested plant residue, primarily stems, from the previous year. These structures often produce conidiophores and conidia early in the spring at the time when leaves first emerge from the soil.

Management

Cultural practices — Diseased crop residues should be removed if practical. In the past, growers would often burn off the straw mulch on the beds each autumn, but this is no longer a common practice. Cultural methods that prevent sand-blasting may limit infection.

Selected references

Ellis, M.B., and J.M. Waller. 1974. *Sclerotinia fuckeliana.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 431. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by R.A. Brammall)

▶ 20.3 Damping-off, root rot, seed decay *Figs. 20.3a,b*

Alternaria panax Whetzel in Whetzel & Rosenb.
Fusarium spp.
Pythium spp.
Rhizoctonia solani Kühn
(teleomorph *Thanatephorus cucumeris* (A.B. Frank) Donk) Root-knot nematode *Meloidogyne* sp.
Root-lesion nematode *Pratylenchus penetrans* (Cobb) Filip. & Stek.

Seed decay, damping-off and seedling root rots are caused by a range of organisms that are common in soils or in plant residue as facultative saprophytes. Root damage is often extensive in first-year ginseng gardens, even where soil fumigants have been applied. Damping-off is an important and widespread disease, often leading to a significant reduction in plant stand. These diseases are often poorly diagnosed and have not been well studied. Damping-off fungi and nematodes can attack a wide range of vegetable crops.

Symptoms Seed decay may occur in the seed stratification boxes or in the gardens after planting. The seed coat often remains intact, with interior tissues first developing a cheesy texture, then rotting away. Post-emergent damping-off may appear on individual plants or clusters of plants. Initially, the stems remain erect with the leaves drooping downward *(20.3a),* followed by stem collapse and death of plants. Circular bare patches may develop within the garden *(20.3b).*

Damping-off caused by *R. solani*, *Pythium* or nematodes *(Pratylenchus* and *Meloidogyne* spp.) results in plants with a water-soaked or brown rot of the roots or below-ground portion of the stem. *Pratylenchus penetrans* may also be found in root tissue with these symptoms (see Potato, 16.38). In contrast, *Alternaria panax* produces girdling and brown stem lesions above the soil line *(20. 1b)* (see alternaria blight, 20.1).

Although root damage often leads to plant death, other plants may exhibit lesser amounts of root or stem damage. In such cases, most of the primary root may be rotted. The production of secondary roots may permit the plant to survive, in which case the damage results in roots with bizarre shapes. The humanoid appearance of some ginseng roots may be a result of these infections.

Causal agents Accurate identification of the cause of damping-off requires isolation and confirmation of pathogenicity of the organisms in inoculation trials. *Pythium, Rhizoctonia, Fusarium, Alternaria panax* and *Pratylenchus penetrans* may be recovered from plants with root-rotting or damping-off symptoms. Bacteria also can cause certain types of damping- off or seed decay. In Korea and Japan, for example, the bacterium *Erwinia carotovora* (Jones) Holland has been implicated in seed decay and red root rot of ginseng. In Ontario, fluorescent pseudomonads and *Fusarium* spp. are commonly recovered from decayed seeds. All of these organisms are common in soils or as saprophytes in plant residue. Because many of them often attack diseased tissues as secondary invaders, much critical work needs to be done before damping-off and root rot diseases are better defined and more easily diagnosed.

Disease cycle Infection may occur before or during germination of seed. Fungal pathogens, such as *Pythium* or *Fusarium,* can produce spores within or upon decaying host tissue. Certain pathogens, especially *Alternaria* species, may be seed-borne. Others can use the straw mulch that covers the raised garden as a pathway for plant-to-plant spread or may spread through the soil from saprophytically colonized bits of plant residue.

Typically, harvested berries are fermented to remove the pulp from the seed, then buried in seed boxes, often filled with sand, for a period of about one year before being recovered and planted in a new garden. This stratification is apparently required to break seed dormancy, although the percentage germination is often poor. Rotting of seeds and premature sprouting of seeds in the box are common. Growers often treat seed with formaldehyde before placing it in a seed box. Fluorescent pseudomonad bacteria and *Fusarium* spp. can be recovered from rotted and partially rotted seeds. It is likely that a percentage of planted seed is infected with such seed-rot organisms, which may kill the seed before germination or cause pre- or post-emergence damping-off. The presence of infected seeds probably causes seed death before germination and spread of seed-rotting organisms causes pre- or post-emergent damping-off. Seed infected by *A. panax* may introduce the pathogen into new gardens, although this has not been documented.

Management

Cultural practices — Seed boxes should be isolated from ginseng gardens to prevent contamination of the seed by infested crop residue or run-off. Losses caused by seed rots, premature sprouting and poor germination could be avoided if stratification procedures were carried out above ground in refrigerated facilities. Unfortunately, the environmental conditions required to break seed dormancy are not well established.

Gardens should be situated on well-drained soils. Growers generally use raised beds to promote drainage but it is not clear whether these are required on sandy soils.

Chemical control — Soil fumigation is often carried out before seeding new gardens. Such procedures destroy beneficial soil microflora and may facilitate establishment and spread of pathogens in the soil. In Ontario, growers generally fumigate soil in late summer before making the raised beds into which seed is planted. Despite fumigation, root-lesion nematodes often can be recovered from damped-off seedlings in the year after planting. Growers in British Columbia may or may not fumigate, depending on local nematode populations or previous experience. Registered fungicides are available for control of damping-off caused by *R. solani.*

Selected references

Mordue, J.E.M. 1974. *Thanatephorus cucumeris.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 406. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by R.D. Reeleder)

▶ 20.4 Disappearing root rot *Figs. 20.4a,b*

Cylindrocarpon destructans (Zinssmeister) Scholten
(teleomorph *Nectria radicicola* Gerlach & L. Nilsson)

Disappearing root rot affects plants of all ages and has been a major problem in south-central Ontario for over 50 years. The nearly total destruction of the root gives the disease its common name. The disease occurs in the northern United States and in Korea and China. In Ontario, it may occur in a broad range of different soil types and may cause severe plant losses in individual gardens. *Cylindrocarpon destructans* is common in soils of coniferous woodlands and is an important pathogen in tree nurseries. Whether it persists on organic residues in garden sites is unknown.

Symptoms The disease affects all of the subterranean portions of the plant. Diseased plants may fail to emerge in the spring or they repeatedly wilt and recover, but the aerial portions are usually killed. Small, discolored, gold to brown areas appear on the root surface in the early stages of infection *(20.4a).* The lesions are shallow at first, then enlarge rapidly and deepen, producing a reddish-brown, spongy rot below the level of the periderm. The exterior of the root develops a dark brown discoloration at infection sites during the more advanced stages of the disease *(20.4b).* Lateral rootlets may be affected, producing a distorted taproot. The rot may progress into the crown and the stem. Attempting to pull such plants from the soil causes the stem to separate from the root. In later stages, only fragments of root periderm and the vascular tissues remain. Damage to the root system produces wilting of the aerial portions of the plant that is often one-sided. The foliage may turn red to brown after repeated wilting. In gardens that are harvested after three to four years, most affected plants have only partially rotted roots.

Disappearing root rot is distinguished from phytophthora root rot by dark-colored lesions and the absence of a persistent soft rot in the cortex. Conidia of *Cylindrocarpon destructans* occasionally may form on the surface of rotted roots. These conidia resemble and may be confused with the macroconidia of *Fusarium* species. (See also rusted root, 20.6.)

Causal agent In North America, disappearing root rot was originally ascribed to *Ramularia panicicola* Zinssmeister, *R. mors-panicus* Hildebrand, and *R. robusta* Hildebrand. The latter species was considered to be less pathogenic than the other two. Now, however, *Cylindrocarpon* is preferred over *Ramularia* based on criteria such as conidial and cultural characteristics. In China, this root rot is reported to be caused by *Cylindrocarpon destructans.* It is likely that C. *destructans* is also the correct name for the pathogen in Canada.

The septate hyphae vary from less than 1 to 4 µm in width and are mostly hyaline in culture. Melanized hyphae eventually arise and may produce brown chlamydospores upon aging. The thick-walled chlamydospores are mostly intercalary, solitary or in chains of two to four, and have a diameter of 12.5 to 20.0 µm. Conidia form on and within the rotted root tissues. Eventually, thick-walled, brown-pigmented, globose chlamydospores form and are presumed to be the overwintering stage. Microconidia are oval to elliptical, 6 to 10 by 3.5 to 4 µm, while the one- to five-septate macroconidia are cylindrical with rounded ends, 20 to 40 by 5 to 6.5 µm.

The fungus can be isolated from the margins of young lesions by washing off any adhering soil from the roots, then surface sterilizing them in 0.6% sodium hypochlorite for five minutes. Tissue segments may be plated onto potato-dextrose agar amended with 75 ppm streptomycin sulphate to minimize bacterial contamination. Macro- and microconidia and chlamydospores are readily produced in pure culture on potato-dextrose agar, on which colonies grow relatively slowly, attaining 10 to 12 mm in seven days, with the mycelium changing from grayish-white to brown to deep red-brown.

Disease cycle Disappearing root rot is characterized by concentrically expanding patches of wilting or dead plants in the garden. The pathogen can spread by conidia that form on the surface of rotted roots and are carried on clothing or machinery throughout the garden when machinery or workers move infested soil. Dense plant populations may allow direct plant-to-plant spread of the disease at points of root contact.

The fungus is believed to overwinter as thick-walled chlamydospores in soil or on infested plant residue. The disease occurs in a wide range of soil types. It has been reported to be less severe in soil with pH below 6.5. *Cylindrocarpon* is common in coniferous woodland soils.

Management

Cultural practices — High plant densities favor rapid plant-to-plant spread of the disease. A soil pH of less than 6.5 may limit the incidence of disappearing root rot.

Chemical control — Soil fumigation before planting may reduce levels of *Cylindrocarpon* inoculum.

Selected references

Bei, R.L., and Z.Q. Wang. 1986. Studies on the latent infection of the pathogen causing ginseng rootrot and its control. *Acta Phytopathol. Sinica* 16:41-46.

Booth, C. 1967. *Nectria radicicola.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 148. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

Hildebrand, A.A. 1935. Root rot of ginseng in Ontario caused by members of the genus *Ramularia. Can. J. Res.* 12:82-114.

Matsuo, T., and Y. Miyazawa. 1984. Scientific name of *Cylindrocarpon* sp. causing root rot of ginseng. *Ann. Phytopathol. Soc. Jpn.* 50:649-652.

(Original by R.A. Brammall)

▶ 20.5 Phytophthora mildew and root rot *Fig. 20.5*

Phytophthora cactorum (Lebert & Cohn) J. Schrot.

Phytophthora mildew and root rot has occasionally caused epidemics in Ontario, British Columbia and the United States. All parts of the plant are affected and spread through a garden may be rapid. The disease tends to be more serious in older gardens.

Phytophthora cactorum is found on a number of different plants, most commonly in southern Ontario and British Columbia on fruit trees. However, it has not been found infecting any other plants or weeds in the vicinity of ginseng gardens.

Symptoms Phytophthora mildew produces a leaf spotting that is initially similar in appearance to that caused by *Alternaria* and *Botrytis.* Lesions are water-soaked and dark green, and the center later becomes whitish. Leaflets of diseased plants collapse downward from the base of the petiole and the stems become hollow and brown. Phytophthora lesions lack the yellow-brown margins associated with *Alternaria* infections or the gray surface mold associated with *Botrytis.*

Infection of the roots by *Phytophthora* causes a light brown discoloration of the surface. Symptoms often appear first on the crown and extend down the tap root or they may develop further down on the root system. The interior of rotted roots is creamy white with a soft texture *(20.5).* Squeezing infected roots by hand often causes the soft inner tissue to extrude like toothpaste from a tube. Broad, aseptate hyphae ramify throughout the affected tissues. Thick-walled oospores are common. The foul odor sometimes associated with *Phytophthora*-rotted roots is usually due to secondary colonizers.

Causal agent In northeastern North America, the disease is attributed to infection by *Phytophthora cactorum,* which produces broad, mostly aseptate hyphae. Septa may delimit sporangiophores from the mycelium. Airborne dispersal of zoosporangia has caused severe epidemics in the mid- western United States. In Korean ginseng, *Panax pseudoginseng* Wallich, oospores form in all infected tissues except the roots. Other fungi, including *Pythium* sp., are frequently isolated from affected roots.

In culture, hyphae vary from 2.5 to 5 µm in width but they appear to be wider in the host. The thick-walled oospores produced in culture are roughly spherical to elliptical and vary between 10 and 20 pm in diameter or axial length.

Disease cycle In the foliar mildew phase, zoosporangia produced on leaf lesions are spread by rain or wind to new plants where they establish new infections. The disease is favored by cool, wet or humid weather conditions. Phytophthora crown and root rot often is found where soils are excessively heavy and drainage is poor, or along the lower edges of the raised beds where water often pools. At such sites, diseased plants occur in groups. Zoospores are the probable means of plant-to-plant spread in the soil. Oospores are produced within the rotted tissues and are the likely overwintering stage.

Management

Cultural practices — Removal of affected plants has been recommended, but the practice is rarely practical. Growers should avoid planting in excessively heavy or poorly drained soils.

Selected references

Ohh, S.H., and C.S. Park. 1980. Studies on *Phytophthora* disease of *Panax ginseng* C.A. Meyer: its causal agent and possible control measure. *Korean J. Ginseng Sei.* 4:186-193.

Waterhouse, G.M., and J.M. Waterston. 1966. *Phytophthora cactorum.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 111. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by R.A. Brammall)

▶ 20.6 Rusted root (rusty root) *Fig. 20.6*

Cylindrocarpon sp.

Rusted root of ginseng was first reported in New York State in 1909 and in southwestern Ontario in 1927. The disease causes a superficial, reddish scabbing of the root, downgrading its quality or causing it to be culled. Rusted root is a common problem and may be locally severe in some gardens.

Symptoms In early stages of infection, rusted roots display slightly raised, reddish-brown lesions ranging in size from minute flecks to enlarged areas that girdle the root *(20.6).* All ages of plant and regions of the root may be affected. The lesions give the root a rough appearance. In later stages of infection, the lesions grow together and may cover most of the root surface. The infection remains superficial. The periderm ruptures and sloughs in a manner similar to that seen in common scab of potato. The rusted tissue is easily scraped off the root to reveal healthy white tissue of the underlying cortex. Affected plants may be slightly stunted and mature earlier in the season than normal. They are not killed.

Causal agent Early work in New York suggested that *Chalara elegans* Nag Raj & Kendrick was the causal agent. Subsequent studies showed that *Ramularia* species *(Ramularia destructans* Zinnsmeister and *R. panicicola* Zinnsmeister) caused the disease in New York and Wisconsin. In Ontario, the cause of the disease is also thought to be a *Ramularia* species. A species of *Cylindrocarpon* has been associated with rusty root in British Columbia, and perithecia of *Nectria galligena* Bres. *in* Strass, have been observed on ginseng seed. The correct designation for the pathogen is likely *Cylindrocarpon destructans* (Zinnsmeister) Scholten (see disappearing root rot, 20.4). Rusted root and disappearing root rot are probably related disorders. Whether differences between these two diseases reflect soil, environmental, host or pathogen factors is unknown.

Disease cycle (see disappearing root rot, 20.4)

Management (see disappearing root rot)

Selected references

Hildebrand, A.A. 1935. Root rot of ginseng in Ontario caused by members of the genus *Ramularia. Can. J. Res.* 12:82-114.

(Original by R.A. Brammall)

▶ 20.7 Sclerotinia white rot *Fig. 15B.9T1*

Sclerotinia sclerotiorum (Lib.) de Bary
(syn. *Whetzelinia sclerotiorum* (Lib.) Korf & Dumont)

Sclerotinia sclerotiorum (see Carrot, sclerotinia rot, 6.15) occasionally causes a stem and root rot of ginseng. Infected foliage wilts, discolors and dries up. Diseased roots show no discoloration but become soft and watery. Black sclero- tia often form on infected plant parts.

Management

Cultural practices — To manage this disease, growers should remove and destroy infected plants to reduce inoculum build-up, and avoid cultural practices that promote dense plant canopies, which favor white rot development.

Selected references

Mordue, J.E.M., and P. Holliday. 1976. *Sclerotinia sclerotiorum.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 513. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by L.S. MacDonald and R.J. Howard)

▶ 20.8 Verticillium wilt

Verticillium dahliae Kleb.

Verticillium wilt generally affects ginseng plants in older gardens. The disease has been reported from the northern United States but not in Canada. Early publications on diseases of ginseng refer to this disease as acrostalagmus wilt, a name that has been retained in error in some popular publications. Verticillium wilt may have declined in importance with the adoption of relatively short, three to four year cropping cycles. *Verticillium dahliae* has a wide host range and may persist on symptomless weed hosts.

Symptoms Affected plants display wilting of the foliage.

In diseased plants, the leaves wilt and droop parallel to the stem. This wilting eventually kills the plant. Roots are firm but the vascular tissue is conspicuously discolored yellow. Microscopic examination of root cross-sections reveals the vessels to be colonized by fungal hyphae.

Causal agent (see Potato, verticillium wilt, 16.20)

Disease cycle (see Potato, verticillium wilt, 16.20) *Verticillium dahliae* overwinters as microsclerotia in infected plant tissues. The fungus infects ginseng by penetrating into the vascular tissue at the sites of leaf scars. The fungus likely can also penetrate roots directly. It grows within and spreads through the xylem vessels. Microsclerotia form in tissues that have been killed by the fungus. The optimum temperature for verticillium wilt is generally below 20°C. Symptoms may not appear until later in the season when the plants become senescent.

Management

Cultural practices — Removal of affected plants may reduce inoculum in the garden. Infested soil may be moved throughout a garden on machinery, so steps should be taken to disinfest it between plots.

Chemical control — Soil fumigation before planting may reduce levels of *Verticillium* inoculum.

Selected references
Hawkesworth, D.L., and P.W. Talboys. 1970. *Verticillium dahliae.* CMI Descriptions of Pathogenic Fungi and Bacteria, No. 111. Commonw. Mycol. Inst., Kew, Surrey, England. 2 pp.

(Original by R.A. Brammall)

NON-INFECTIOUS DISEASES

▶ 20.9 Nutritional and other disorders *Figs. 20.9a-d*

Zinc deficiency
Phytotoxicity
Sunscald

Zinc deficiency causes interveinal yellowing *(20.9a).* In severe cases, the interveinal areas become white while the large veins remain dark green.

Foliar applications of zinc are effective but can be toxic except in very low amounts. Growers are advised to have the soil tested for adequate levels of plant nutrients before planting.

Phytotoxicity Mancozeb fungicide applied at the full label rate during hot weather has caused red ring spots and necrotic blotches *(20.9b)* on the leaves of ginseng seedlings in British Columbia. Mancozeb toxicity has not been observed in Ontario, but anilazine has sometimes caused damage when applied at greater than label rates during hot weather.

Growers in British Columbia routinely use half the label rate or less of mancozeb on one-year plants to reduce phytotoxicity. To minimize fungicide toxicity *(20.9c),* growers should be cautious about applying these fungicides when air temperatures exceed 30°C.

Sunscald Ginseng is a shade-loving herb that grows naturally only where there is a minimum of 70% shade. The leaves are very easily damaged by high intensity light, so cultivated ginseng must be grown under shaded conditions that match its native habitat in the forest understory. Direct sunlight burns leaf tissues, causing them to wilt, turn brown and die *(20.9d).* The proper use of shading materials will prevent this type of damage from happening.

(Original by L.S. MacDonald and R.J. Howard)

NEMATODE PESTS

▶ 20.10 Northern root-knot nematode

Meloidogyne hapla Chitwood

Symptoms Mature roots may be deformed, short and branched, and secondary roots abnormally branched and hairy. For a complete description and management strategies, see Carrot, 6.20; see also Management of nematode pests, 3.12.

INSECT PESTS

▶ 20.11 Miscellaneous insect pests

Cutworms
Thrips
Weevils
Wireworms

Cutworms were first documented in ginseng plantations in Canada in May and June, 1989, in Norfolk County in southern Ontario.

Thrips damage to flower heads was first documented on ginseng in Canada in 1989, also in Norfolk County, southern Ontario.

Weevils have been a problem at a garden on Vancouver Island, British Columbia.

Wireworms have caused stem and root damage in British Columbia.

Management

Chemical control — Insecticides have not been registered in Canada for control of these pests on ginseng.

Selected references

Cheng, H.H. 1990. Insects and related pests of miscellaneous crops/Les ravageurs de cultures diverses. Ginseng. Page 48 *in The Canadian Agricultural Insect Pest Review/La revue canadienne des insectes nuisibles aux cultures.* Vol. 67 (1989). 90 pp.

(Original by H.H. Cheng, B.F. Zilkey and L.S. MacDonald)

OTHER PESTS

▶ 20.12 Slugs *Figs. 11.27a-c*

Many growers attempt to control slugs in Ontario gardens, according to R.A. Brammall. For information about slugs, see Crucifers, 8.49; Lettuce, 11.27.

ADDITIONAL REFERENCES

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