BRITISH COLUMBIA | Ministry of Agriculture

Diseases of Cannabis in British Columbia

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This factsheet will describe the symptoms, casual agents, and management strategies for the most critical diseases of cannabis in British Columbia (B.C.). These include root and crown rots, powdery mildew, bud rots, and post-harvest flower moulds. This information should help cannabis growers to improve their understanding of these diseases and adopt appropriate management practices to limit the introduction, establishment, and spread of the pathogens as well as reduce the damage they cause to cannabis production in B.C.

Fusarium Crown Rot, Root Rot, and Damping-off (*Fusarium* spp.)

Description and Distribution

Fusarium spp. are soilborne pathogens that cause root rot, crown rot, wilt and damping-off on cannabis and greenhouse and field crops, including cucumber, tomato, pepper, ornamental crops, and others, throughout the world. Cannabis is affected by several *Fusarium* spp., including *F. oxysporum*, *F. proliferatum* and *F. solani*. These species are present in cannabis production facilities in B.C. and have also been reported from other cannabis growing regions in Canada. *Fusarium* species infecting cannabis are not restricted to cannabis, and may originate from, or spread to, other unrelated or related plant species such as hemp and hops.

Symptoms

Fusarium causes root rot, which appears as brown and necrotic areas on roots, as well as crown rot, which appears as sunken discolored lesions at the base of the plant near the soil line. These lesions can extend up on the stem for several centimeters. Plants may also develop mildly to severely chlorotic foliage, appear stunted, and less commonly, may wilt due to the damage to the roots and vascular system (Fig. 1A, B). When stems of diseased plants are cut open, the pith and xylem tissues may appear brown or black due to infection by the pathogen (Fig. 1D, E). Whitish-pink mycelium of the pathogen may be seen in the crown area along with spores produced by the pathogen.

Cannabis cuttings that are being propagated may also be affected by *Fusarium*, causing symptoms of damping-off. Lesions typically start at the base of the cuttings and affected tissues appear soft, discoloured and necrotic. The cuttings will often wilt, collapse, and die (Fig. 1C). Mycelium of the pathogen appears as off-white, light pink or light orange growth on the affected tissues, especially under high humidity. Production of spores by the pathogen may also be abundant under these conditions. *Fusarium* species infecting cannabis can grow over a temperature range of 15-30°C, although the disease can occur at higher temperatures as well.

Figure 1: Symptoms of *Fusarium* diseases on cannabis plants. (A, B) Severe chlorosis and stunting of cannabis plants. (C) Damping-off on cuttings. White mycelium of *Fusarium* is visible on the stems. (D, E) Cross sections of cannabis stems showing discoloured and necrotic pith and xylem tissues.

Spread

Fusarium spores or mycelium can be spread through contaminated soil, water, equipment, tools and potentially by workers. Spores may also be released and spread through the air. The primary source of *Fusarium* infection is through cuttings taken from infected stock (mother) plants, as the pathogen can be present internally in the xylem tissue of infected plants without expressing any symptoms. Producers should ensure that planting materials are obtained from a reliable source. Infection of flowers by *Fusarium* spores can also lead to bud rot. Damage to roots from transplanting, overwatering or extreme fluctuations of moisture in growing media may increase the incidence and severity of the disease. Insects (root aphids, fungus gnats, etc.) may spread *Fusarium* and the damage to roots from insect pests can also enhance *Fusarium* infection.

Pythium Crown and Root Rot (*Pythium* spp.)

Description and Distribution

Several species of *Pythium*, including *P. myriotylum*, *P. dissotocum, P. aphanidermatum* and *P. ultimum*, have been reported to infect cannabis in B.C. and other parts of North America. These pathogens, also known as water moulds, affect many greenhouse crops, including pepper, tomato, cucumber and ornamentals, as well as several other field crops such as strawberry. The host range of the *Pythium* species infecting cannabis is therefore broad, and the pathogens may originate from, and spread to, other host plants.

Symptoms

Pythium causes roots to appear brown, rotten and with a distinct lack of feeder roots (Fig. 2). The outer region of infected roots may easily slough off, leaving only the vascular tissue intact. Symptoms of crown rot appear as dark, sunken lesions at the base of plants which can extend several centimeters up on the stems. Infected plants are often stunted, and leaves may later turn yellow. Wilting occurs rapidly under warm and sunny conditions. Diseased plants may emit an odor due to secondary invasion by bacteria, especially during warm weather.

Figure 2: Symptoms of *Pythium* infection on cannabis plants. (A) Brown necrotic roots. (B) A stunted, wilting plant in flower, where infected plants may remain green although their roots are significantly damaged. (C) Death of a plant.

Spread

Pythium produces mycelium, water-borne spores (zoospores), as well as long-lived oospores, on diseased plants and in growing media. These can subsequently be spread by water, contaminated growing media, insects, and plant debris. Contaminated tools and equipment, including irrigation systems, may also spread *Pythium*. Root damage and overwatering can contribute to *Pythium* infection. The pathogen can grow at temperatures of 10-35°C, although it is favours temperatures around 30°C.

Powdery Mildew (*Golovinomyces* spp.)

Description and Distribution

Powdery mildew is caused by *Golovinomyces* species, including *G. cichoracearum*, *G. ambrosiae* or *G. spadiceus*. These pathogens are present in B.C., eastern Canada, the USA and likely elsewhere. The host range of the pathogens may include other, yet undetermined, plant species. On outdoor grown cannabis and hemp, powdery mildew infection may also be caused by *Podosphaera macularis*, the causal agent of powdery mildew on hops. Infection by the pathogen from hops to cannabis and hemp has been reported in B.C. and New York state, but is found infrequently.

Symptoms

Powdery mildew may affect plants at all stages of growth and the symptoms can be seen on leaves, flowers and occasionally on stems (Fig. 3). On the upper surface of leaves, flowers and occasionally stems, the mycelium and conidiophores (i.e. spore producing structures) of the pathogen appear as distinct white powdery patches. Masses of spores are produced and released when plants are disturbed. Powdery mildew infection may cause leaves to turn brown and drop prematurely. Diseased plants may also be stunted, with poor quality flowers. The effects on overall yield are not known. Powdery mildew infections are localized to the infected tissues. Systemic infections and internal spread of the pathogen have not been demonstrated.

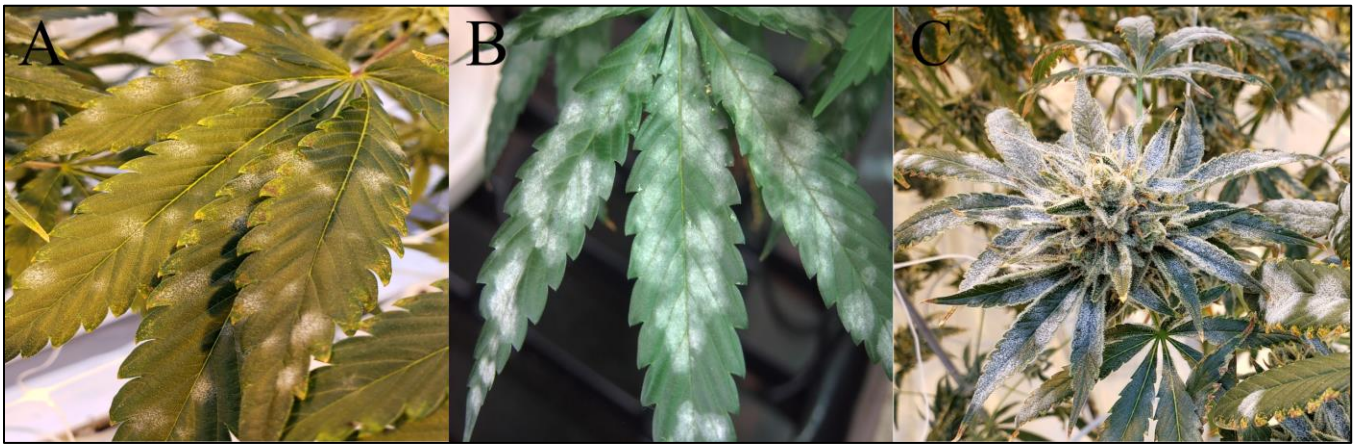

Figure 3: Powdery mildew on cannabis. (A, B, C) Moderate to severe powdery mildew infection on leaves and flowers.

Spread

Spores of *Golovinomyces* spp. spread primarily through the air, although contaminated clothing, equipment and tools may also spread the pathogen to a lesser extent. The pathogen may be introduced into a growing facility on infected plants, including cuttings or mother plants. The severity and incidence of powdery mildew infection is enhanced by rapid temperature and humidity fluctuations, high humidity, and inadequate air movement. Cannabis strains may differ in their susceptibility to powdery mildew, with some showing apparent resistance to the disease. Therefore, selection of cannabis strains that are resistant to powdery mildew is important.

Bud Rot (*Botrytis cinerea*)

Description and Distribution

Botrytis cinerea, also known as "grey mould", is the major cause of bud rot in B.C. and other regions of Canada and the USA. The pathogen can also cause stem canker on cannabis. The range of plant species that can be affected by *Botrytis* is extensive and includes over 500 species. Examples of affected crops in B.C. include strawberry, blueberry, raspberry, tomato, pepper, grape, tree fruits, and others. The pathogen can readily spread from one host to another by windblown spores.

Symptoms

Buds (inflorescences) affected by *Botrytis* initially appear soft and discoloured. As symptoms progress, buds may turn crisp and brown (Fig. 4A). Infections commonly start in the interior of the buds, where humidity is highest and air movement is lowest, and progress outwards (Fig. 4B). Grey or off-white mycelial growth may also be observed on affected buds. Under high humidity, the pathogen will sporulate and produce characteristic grey mould (Fig. 4C). Stem cankers appear as slightly sunken tan or off-white areas on the main stem or at branching

points where an injury has occurred. Grey sporulation is also often observed on the cankers. Most infections take place during the early fall and winter seasons, and only rarely during the warm summer months. The pathogen does not grow at temperatures over 30°C but can grow at 5-10°C.

Figure 4: Cannabis (inflorescences) affected by *Botrytis*. (A) An infected bud, with visible grey mycelium. (B) A dense flower affected by bud rot, with distinct discoloured necrotic tissues. (C) Severe infection on a cannabis flower showing abundant spores.

Spread

Botrytis spreads primarily as spores through the air. Spread may also occur from infected plant debris, tools, equipment and on the clothing of staff and visitors. Adjacent crops that are susceptible to grey mould may be a source of spores. The disease is favored by high relative humidity, as well as poor air circulation and condensation of moisture on plant surfaces. Damaged plant tissues are more susceptible to infection. Plants receiving excessive levels of nitrogen may also be predisposed to *Botrytis* infection. The risk of infection of inflorescences resulting in bud rot is greater as buds reach maturity. Cannabis strains with large inflorescences with many closely packed flowers are more susceptible to infection compared to those with a loosely arranged flowers.

Post-Harvest Decay

Description and Distribution

Several fungi can cause post-harvest rot and decay of buds, including species of *Penicillium*, *Fusarium*, *Aspergillus, Cladosporium* and *Botrytis*. These fungi gain access to bud tissues prior to harvest or during the post-harvest trimming, drying and curing of harvested buds. The occurrence of post-harvest mould on the cured buds can

increase the total yeast and mould counts, as well as reduce the appearance and quality of the buds. Post-harvest rot or decay is more common under humid growing environments or where management of the post-harvest environment is inadequate. Some cannabis strains that are more prone to injury may show a high frequency of post-harvest rot or decay.

Symptoms

Affected buds appear soft and discolored. Aerial masses or small spots of white, grey, or off-white mycelium are usually visible on affected tissues, typically 2-5 days after harvest. On dried buds, darkened areas with fungal spores can be seen.

Figure 5: Post-harvest decay of harvested cannabis buds. (A) A large patch of *Botrytis* mycelium on buds as well as a bud affected by *Penicillium* above it. Discoloration and white mycelium can be observed. (B) *Penicillium* and other fungal species growing on harvested buds. Small patches of white mycelium are visible on buds.

Spread

Post-harvest fungi on harvested buds are ubiquitous and may originate from the air, growing media and plant debris. They are spread through the air or on contaminated equipment, tools or the hands and clothing of workers. Trimming and curing areas for harvested buds with poor ventilation can cause excessive levels of mould to build up. Wounds incurred during harvest and trimming as well as inappropriate drying conditions (humidity, temperature, airflow) can also contribute to post-harvest decay.

Virus and Viroid Diseases

Description and Distribution

Confirmed reports of viruses affecting cannabis plants are few. However, samples recently diagnosed using molecular approaches confirm that *Tobacco mosaic virus*, *Cucumber mosaic virus* and *Alfalfa mosaic virus* are present in cannabis plants in B.C. These viruses also have wide host ranges and affect other commonly grown crops such as tomato, cucumber, and other vegetables. Hop Latent Viroid (HLVd) has been reported to infect cannabis and is present in California, other areas of the USA and Canada. HLVd also infects hops and is distributed in hop growing regions around the world, where it causes no symptoms (i.e. they remain latent).

Symptoms

True virus symptoms include alternating patterns of yellow and green (mosaic), yellowing on certain parts of the plant, or curling, distortion and narrowing of young leaves. In addition, line patterns may be produced on diseased leaves (Fig. 6). The effects of viruses on cannabis yield and flower quality have not been determined.

Symptoms of HLVd include stretched and horizontal plant growth, brittle stems, malformed or chlorotic leaves and stunting. Plants may also "dud" when flowered, with flowers appearing small and malformed. The production of secondary metabolites, such as cannabinoids, and yield are also negatively affected. Plants may remain asymptomatic but still harbour HLVd or viruses.

Virus disease symptoms may be easily confused with nutrient deficiencies, such as iron, magnesium or nitrogen, that cause yellowing or striping of leaves. In addition, other abiotic stresses causing distortion or curling of leaves may appear similar to a virus disease. Stunted growth due to poor growing conditions may resemble a virus infection, especially if accompanied by foliar symptoms. Herbicide injury can resemble the symptoms of virus infection.

Figure 6: Symptoms of virus and viroid infection. (A) Young leaves are light green with alternating patterns of yellow. (B) Malformed leaves caused by Hop Latent Viroid on a plant growing vegetatively. (C, D) Older leaves with yellow and green striking pattern of mosaic.

Spread

These viruses and viroids may be brought into the growing environment via infected mother plants, cuttings and potentially seeds. HLVd and viruses can spread with the use of contaminated tools, equipment and on the hands and clothing of staff, especially during pruning and handling of plants.

Other emerging pathogens

Below is a list of other potentially important pathogens that have been observed on cannabis in B.C. that producers should be made aware of:

Alternaria stem canker and bud rot
Sclerotinia stem canker and bud rot
Stem cankers caused by *Diaporthe*, *Neofusiccocum* and *Lasiodiplodia* spp.

Control Measures for Cannabis Diseases

In general, maintaining clean and sanitary conditions in cannabis growing facilities can reduce the incidence of many diseases. Minimizing the potential spread of pathogens by using footbaths at the entrances to the cannabis growing areas and the use of hair nets, beard nets and gloves for visitors and staff is important.

Air filtration and purification systems such as HEPA filters and UV may also be used to reduce airborne contaminants and pathogens. Tools, equipment, dehumidifiers, air filters, and growing and trimming rooms, should be regularly cleaned and sanitized.

Maintain appropriate humidity and air-temperature levels and improve air circulation in cannabis production and post-harvest processing (drying) areas to prevent or minimize powdery mildew, *Botrytis* bud rot and post-harvest decay. Minimize damage to buds during harvest and trimming to reduce post-harvest bud decay.

Treat irrigation water with UV, chlorine, or other registered products to prevent the spread of pathogens responsible for root rot, crown rot and damping-off.

Scout for and remove diseased plants and plant tissues from cannabis growing or post-harvest processing areas to minimize the buildup of inoculum and the spread of disease.

Plant disease resistant cannabis strains where possible. Use disease-free planting stock or cuttings from healthy mother plants for propagation. Producers should ensure that new plant materials entering the growing facility, such as cuttings or planting stock, are quarantined and inspected for disease symptoms or the presence of insect pests.

Diseased samples can be submitted to the Ministry of Agriculture, Food and Fisheries - Plant Health Laboratory or commercial laboratories to test for the presence of pathogens.

Table 1. A summary of registered chemical and biological fungicides and application information. Please refer to Health Canada's Pest Management Regulatory Agency website for the manufacture's label and strictly follow the instructions as outlined in the label.

Product name	Active ingredient	Chemical or biological group	Disease	REI[1] hrs	PHI[2] days	Application guidelines
Actinovate SP or CannaPM	*Streptomyces lydicus* WYEC 108	biological	Grey mould Powdery mildew Root rot Damping-off	4	14-21	Apply preventatively to foliage/blooms or growing media/soil and repeat at 7-14 days intervals as needed.
Agrotek	Sulphur	M	Powdery mildew	2	NA	Run the vaporizer for 1-8 hrs per night and repeat 2-7 times per week as needed.
Asperello T34	*Trichoderma asperellum* T34	biological	Wilt Root / Crown rot Damping-off	4	NA	Apply preventatively to growing media/soil as needed.
Bartlett	Sulphur	M	Powdery mildew	24	NA	Apply at onset of first symptoms and at weekly intervals. Do not exceed 10 applications per crop cycle.
Cyclone	Citric acid + Lactic acid	biological	Powdery mildew	4	0	Apply at onset of first symptoms and at 7-10 days intervals as needed.
Double Nickel LC or 55	*Bacillus amyloliquefaciens D747*	biological	Grey mould Powdery mildew White mould	NA	21-28	Apply preventatively to growing media/soil or as foliar spray at 3-14 days intervals as needed.
Influence LC	Garlic powder	biological	Powdery mildew	until dry	0	Apply at onset of first symptoms and at 7- 10 days intervals as needed.
Lacto-San	Citric acid + Lactic acid	biological	Powdery mildew	4	0	Apply at onset of first symptoms and at 7-14 days intervals as needed.
MilStop	Potassium bicarbonate	M	Powdery mildew	until ventilated	NA	Apply at onset of first symptoms and at 7-14 days intervals as needed.
PreStop	*Gliocladium catenulatum* J1446	biological	Root / Crown rot	NA	0	Apply preventatively to growing media/soil. Repeat every 3-6 weeks as needed.
Regalia Maxx	*Reynoutria sachalinensis* extract	biological	Grey mould Powdery mildew	until dry	0	Apply at onset of first symptoms and at 7-14 days intervals as needed.

RootShield HC	*Trichoderma harzianum* T22 (KRL-AG2)	biological	Grey mould	4	0	Apply preventatively at 7-14 days intervals.
RootShield WP, RootShield Granule, RootShield Plus, BW240	*Trichoderma harzianum* T22 (KRL-AG2)	biological	Root / Crown rot Damping-off	4	0	Apply to growing media/soil at planting and repeat after 8-10 weeks if disease is suspected.
Sirocco	Potassium bicarbonate	M	Powdery mildew	4	NA	Apply at onset of first symptoms and at 7-14 days intervals as needed.
Trianum P	*Trichoderma harzianum* T22	biological	Root / Crown rot Damping-off	4	0	Apply to growing media/soil at planting and repeat after10 weeks as needed.
ZeroTol	Hydrogen peroxide	M	Grey mould Powdery mildew	4	0	Apply at onset of first symptoms and at a minimum 7-day interval.

REI[1] - re-entry interval
PHI[2] - pre-harvest interval
NA - not available

For Further Information

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