

Hemp and Cannabis Crop Diseases

A guide to field diagnosis and management

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The *Cannabis* Plant

Defining *Hemp*: A Fact Sheet

“Botanically, hemp and marijuana are from the same species of plant, *Cannabis sativa*, but from different varieties or cultivars. However, hemp and marijuana are genetically distinct forms of cannabis that are distinguished by their use and chemical composition as well as by differing cultivation practices in their production. While marijuana generally refers to the cultivated plant used as a psychotropic drug (whether used for medicinal or recreational purposes), hemp is cultivated for use in the production of a wide range of products, including foods and beverages, personal care products, nutritional supplements, fabrics and textiles, paper, construction materials, and other manufactured and industrial goods. *Hemp* and *marijuana* also have separate statutory definitions in U.S. law.”



- Cited from Congressional Research Service
<https://crsreports.congress.gov>

Photos by Shouhua Wang

Types of Cannabis Diseases



Seed infection (latent)

Bud/flower molds

Mites

Foliar diseases

- Powdery mildew

- Leaf spot

- Sooty mold

Systemic diseases

- Phytoplasma

- Viruses

- Viroid

- Vascular wilt

Stem canker/rot

Crown rot

Root rot and infection

- Pythium

- Fusarium

- Nematodes

Diseases affecting buds,
flower and seeds

Diseases affecting foliage

Diseases affecting plants
systematically

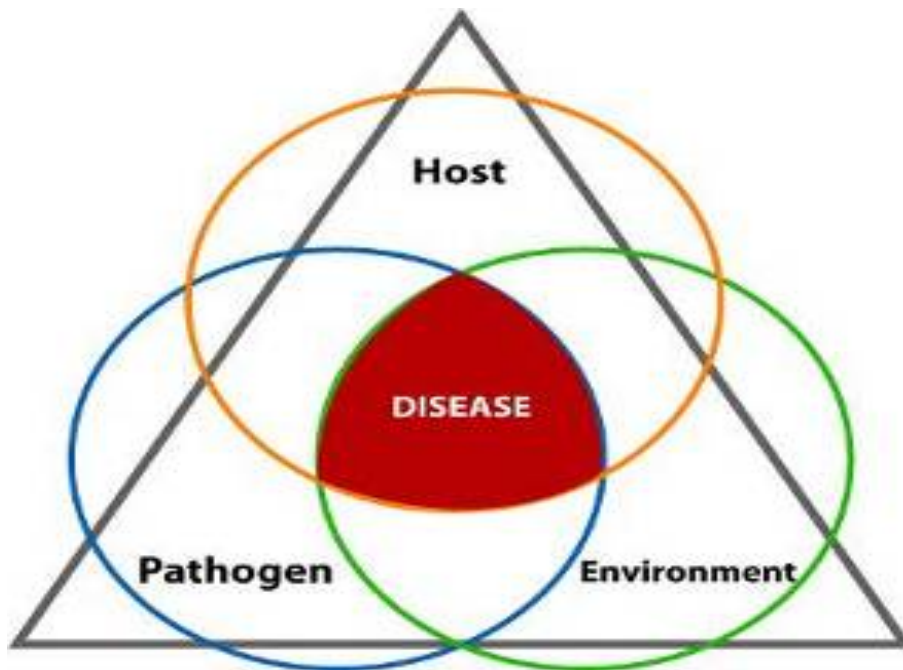
Diseases affecting stem

Diseases affecting roots

Photos by Shouhua Wang

Cannabis Disease Triangle

Hemp or Cannabis (*Cannabis sativa*)



- Fungi
- Bacteria
- Viruses
- Nematodes

- Moisture
- Temperature
- Stress
- Vectors
- More

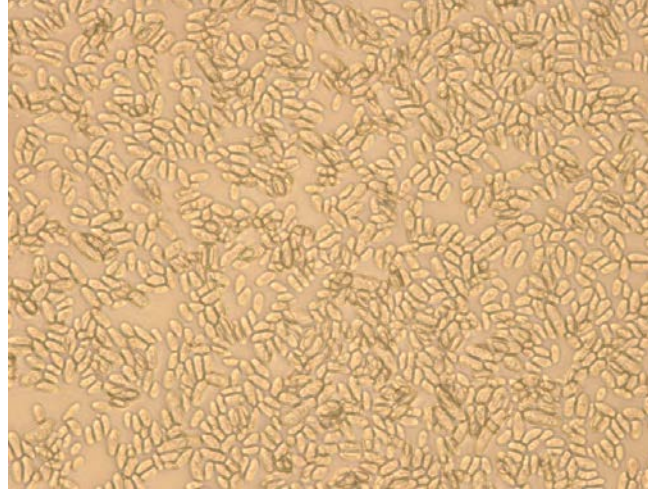
A plant disease is a result of the interaction of these three factors

Plant Pathogenic Fungi

- **Hyphae** (singular hypha): filamentous threads making up the **mycelium** of a fungus
- **Spores**: special cells for dissemination and survival
- **Special Fruiting Bodies**: Pycnidia, mushroom, etc.
- **Diseases**: leaf spot, mildew, blight, wilt, canker, root rot, etc.



Rhizoctonia hyphae (from hemp)



Fusarium spores (from Marijuana)

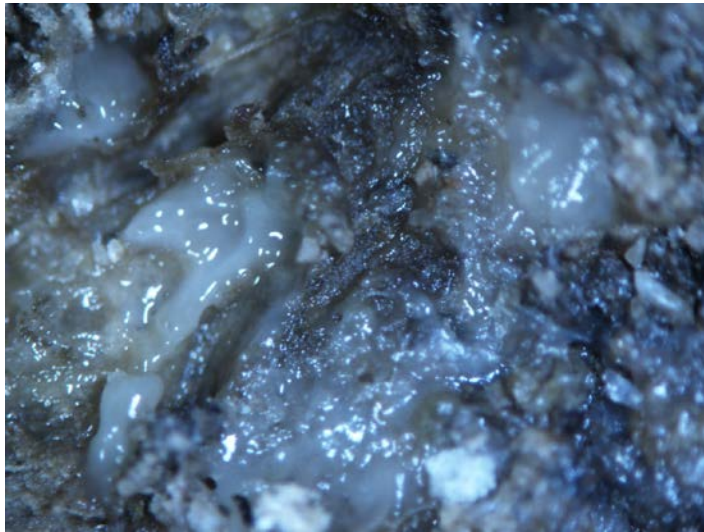


Hemp stem/root rot

Photos by Shouhua Wang

Plant Pathogenic Bacteria

- Microscopic single-celled organisms
- Most plant pathogenic bacteria are bacilliform (rod-shaped)
- Include fastidious prokaryotes – phytoplasmas and spiroplasmas
- Diseases: soft rot, fire blight, leaf spot/speck, wilt, stem and root rot



Slimy growth of bacteria on hemp tissue

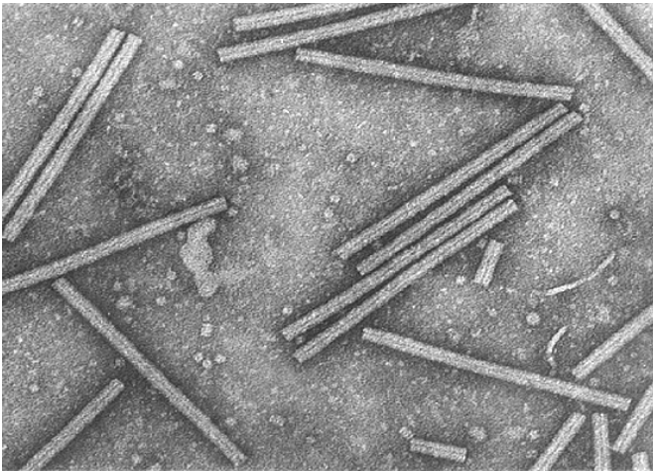


Bacterial streaming from hemp stem

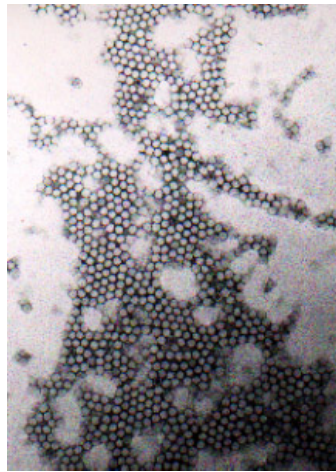
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Plant Viruses and Viroids

- Viruses are infectious, intracellular pathogens that are submicroscopic particles composed of protein and nucleic acid.
- Viroids only have nucleic acid without coat protein.
- Hijack host's nucleic acid replication systems to reproduce.
- Viruses can infect bacteria, algae, fungi, plants, animals and humans.
- Symptoms can be confused with herbicide damage or abiotic stresses.
- Transmitted by wounding, insects, plant parts (seed; propagative tissue).



Tobacco mosaic virus



Tomato ringspot virus



Hemp mosaic

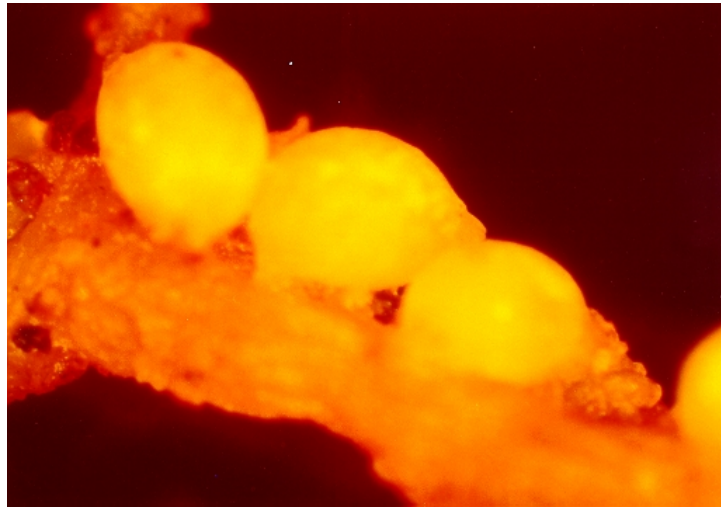
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Plant Parasitic Nematodes

- Non-segmented roundworms
- Most abundant multicellular animals on earth and are free-living
- Parasitic nematodes possess specialized feeding structures
- Soil-borne pathogens that attack roots; a few species attack stems and leaves



Root-knot caused by the nematode



Cyst nematode feeding on root



Lesion nematode
- Migratory endoparasites

Photos by Shouhua Wang

Manage Cannabis Diseases

Challenges in Managing Cannabis Diseases

- Lack of resistant varieties
- Disease pressure from field or greenhouse production
- Lack of rapid diagnostic services
- Lack of IPM strategies specifically for cannabis crop production
- Restrictions on fungicide or chemical use

Manage Cannabis Diseases

Solutions to Disease Management

- Preventive measures
 - Source: soil, seeds, plants
 - Carrier: tools, hands, footwear, water, machinery
- Monitoring and early detection
 - Periodically inspections – Daily or weekly
 - In-house or external laboratory testing
- Roguing
 - Diseased / symptomatic plants
 - Undesirable plants
- Alternative treatments
 - Biocontrol or biofungicide, e.g. *Trichoderma* sp.
 - Physical treatments, e.g. adjust growth environment
- Use available chemical-based products

Manage Cannabis Diseases

Preventive Measures

Hemp Crop

- Check seed health and sources
- Know what is in the soil: pathogens and nematodes
 - History of previous crops
 - Disease history in previous crops
 - Get soil-borne pathogens tested;
 - *Fusarium* (root rot, wilt)
 - *Pythium* (root and crown rot, stem canker, etc.)
 - All nematodes (damage to root and induce fungal or bacterial infection)

Cannabis Cultivation

- Check mother plant health
- Remove infected plants ASAP
- Control facility environment
- Know where diseases come from:
 - Original source or mother plants
 - Cuttings
 - Soil or media
 - Water
 - Contact or human traffic
 - Facility or environment

Manage Cannabis Diseases

Hemp Grown in Farmland

- Variable environment (good or bad)
 - May impact plant growth
 - Pathogens are active in growing season and may survive in winter
- Environmental conditions facilitating infection
 - Over head watering (moisture)
 - Environmental stress (drought or heat)
 - Disease pressure from previous crops
 - Pathogen buildup in the soil
- Management Strategies
 - Exclusion, prevention and sanitation
 - Seed treatment
 - Rotation
 - Chemical/biological control



Photos by Shouhua Wang

Manage Cannabis Diseases

Cannabis Plants Grown Indoor

- Consistency of environment (good or bad)
 - Favorable to plant growth
 - Pathogen survives and is active year round
- Environmental conditions facilitating infection
 - High humidity
 - Optimal temperature
 - Crowded plant spacing and lush growth
 - Easy to spread by contact and air/water circulation
- Management Strategies
 - Exclusion, prevention and sanitation
 - Healthy mother plants/cuttings
 - Eradication



Photos by Shouhua Wang

Diseases Affecting Seeds

Seed Infection by *Rhizopus oryzae*



Fungal growth associated with hemp seed germination



Necrotic lesion on tap root

- *Rhizopus* is a fungal pathogen that can cause soft rot of fruit and vegetables and also infects grains or seeds.
- It may cause poor seed germination or damping-off of younger seedlings.
- Seed treatment with diluted bleach solution, hydrogen peroxide, or other disinfectants

Photos by Shouhua Wang

Diseases Affecting Seeds

Seed Infection by *Alternaria*



Fungal growth associated with hemp seed germination



Alternaria species grown out from seeds

- *Alternaria* is an opportunistic fungal pathogen that can cause diseases on many plants species. It is ubiquitous.
- Two species were found from imported hemp seeds:
 - *Alternaria infectoria*
 - *Alternaria tenuissima*
- Seed treatment with diluted bleach solution, hydrogen peroxide, or other disinfectants.

Photos by Shouhua Wang

Diseases Affecting Buds

Bud Infection by Powdery Mildew or Mold Fungi

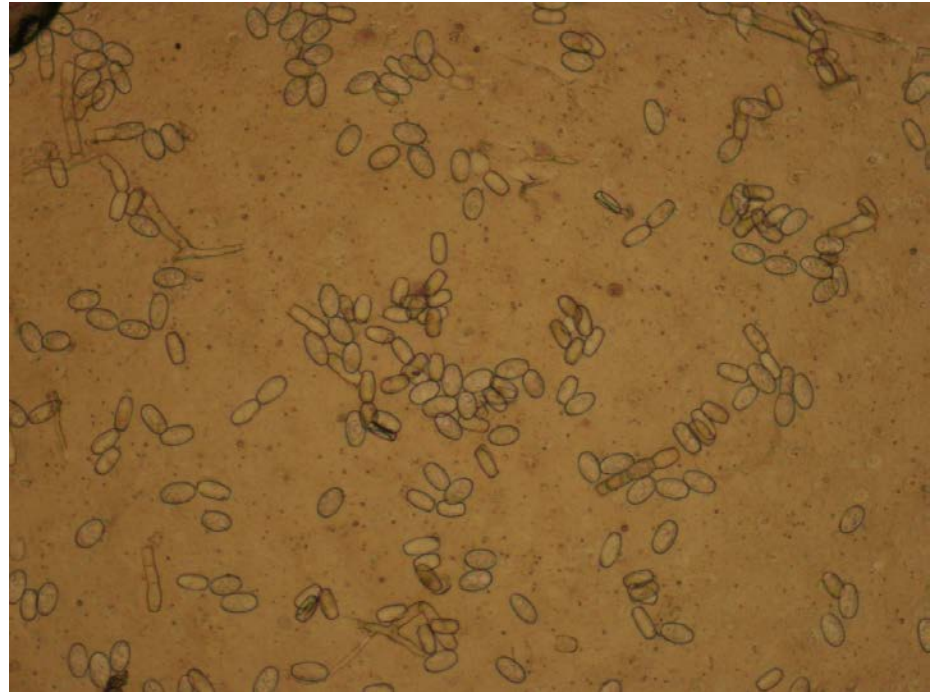


- Powdery mildew on buds
- Other mold diseases affecting buds too
- Treatment depends on the type of mold and its prevalence
 - Lower moisture
 - Eradicate during growing season
 - Keep buds in an open environment to reduce moisture buildup

Photos by Shouhua Wang

Diseases Affecting Leaves

Leaf Infection by Powdery Mildew



Golovinomyces ambrosiae

Photos by Shouhua Wang

Manage Cannabis Diseases

Guidelines for Powdery Mildew Control

- Cultural Control
 - Start with healthy plants and improve plant health
 - Choose resistant varieties if available
 - Monitor early signs of the disease and remove infected leaves or tissue ASAP
 - Prevention and sanitation
- Chemical Control
 - Sulfur and other fungicides labeled for hemp or cannabis crops
 - Prevention
 - Treatment
 - Weekly application depending on disease development
- Environmental Control
 - Temperature: raise temperature
 - Humidity: avoid overhead irrigation, reduce humidity
 - Light: avoid shade
 - Air circulation: increase ventilation (when disease is not present)

Diseases Affecting Leaves

Alternaria Leaf Blight of Hemp



Photos by Shouhua Wang

Diseases Affecting Leaves

Leaf Sooty Mold and Aphids



- Sooty mold associated with aphid infestation
- Multiple fungi found on leaves
- Aphid honeydew is a sugar-rich liquid that fosters fungal growth
- Control aphids to eliminate nutrient source

Photos by Shouhua Wang

Diseases Affecting Stem

Stem Canker Caused by *Fusarium oxysporium* and *solani*



- Discoloration
- Internal Canker or rot
- Whitish mold growth
- Foliage wilt
- Dieback
- Control
 - Avoid the field
 - Rotation
 - Treat soil
 - Treat seeds

Photos by Shouhua Wang

Diseases Affecting Stem

Stem Rot Caused by *Fusarium* sp. and *Pythium* sp.



- Discoloration
- Internal Canker or rot
- Extensive mold growth
- Plant wilt
- Control
 - Reduce soil moisture
 - Avoid the field
 - Rotation
 - Treat soil
 - Treat seeds

Photos by Shouhua Wang

Diseases Affecting Stem

Crown Rot Caused by *Pythium aphanidermatum*



To control:

- Treat seeds with disinfectants.
- Choose a new field or a field where *Pythium* or *Phytophthora* diseases have not been found.
- Reduce soil humidity.
- Don't cover soil with plastic mulch film.

Photos by Shouhua Wang

Diseases Affecting Stem

Crown and Root Rot Caused by Bacteria

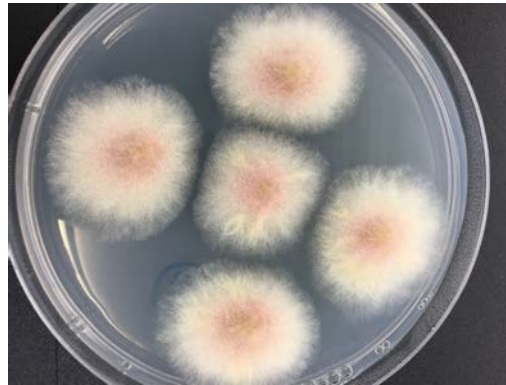


- Internal discoloration
- Internal canker or rot
- Slimy growth
- Plant wilt
- Control
 - Reduce soil moisture
 - Avoid the field
 - Rotation
 - Treat soil
 - Treat seeds

Photos by Shouhua Wang

Diseases Affecting Root

Hemp Root Rot Caused by Single *Fusarium* Species



- Discoloration
- Internal Canker or rot
- Poor root system
- Pink mold growth
- Pre-mature death
- Lack of stands
- Control
 - Avoid the field
 - Rotation
 - Treat soil
 - Treat seeds
 - Reduce drought stress

Photos by Shouhua Wang

Diseases Affecting Root

Hemp Root Rot Caused by Multiple *Fusarium* spp.

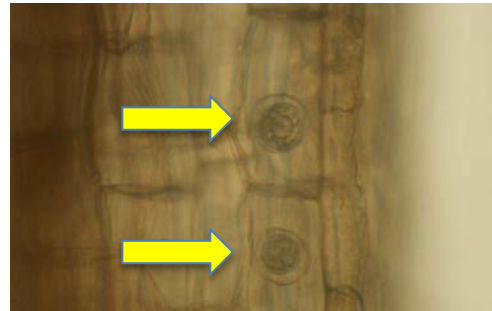


- Discoloration
- Internal Canker or rot
- Pink mold growth
- High mortality
- Control
 - Avoid the field
 - Rotation
 - Treat soil
 - Treat seeds
 - Reduce drought stress

Photos by Shouhua Wang

Diseases Affecting Root

Cannabis Root Rot Caused by *Pythium myriotylum*



Oospore seen inside root



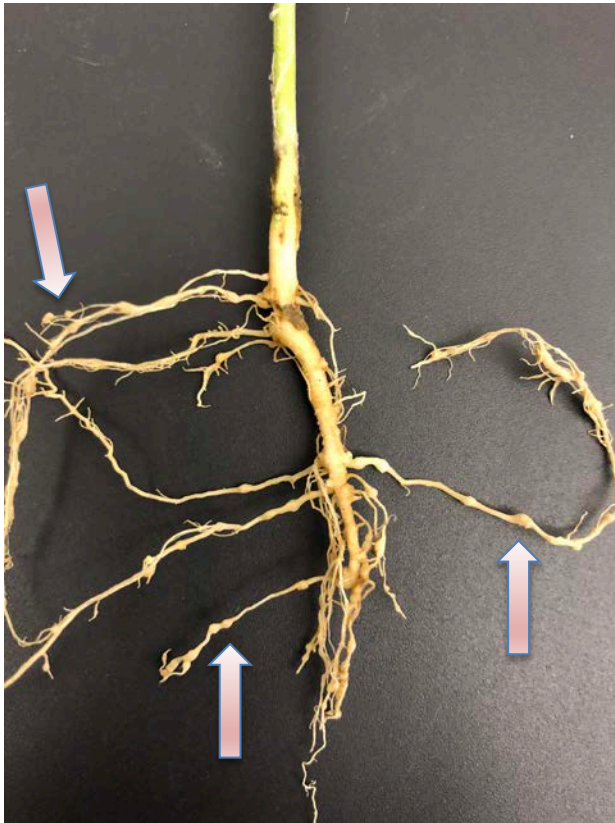
Pythium myriotylum

- *Pythium* is a type of oomycete that likes to live in humid conditions and can be spread through water.
- It is one of most troublesome pathogens on cannabis.
- Early signs of root rot include necrotic lesions and discoloration.
- To prevent the disease, avoid water and fertilizer solution contamination.

Photos by Shouhua Wang

Diseases Affecting Root

Root Knot Caused by the Root-knot Nematode



- Poor growth overall
- Plant may wilt during the mid-day
- Various sizes of knot on roots
- Increase susceptibility to fungal infections
- Control
 - Test soil for nematodes before planting
 - Pre-planting treatment by a nematicide
 - Avoid introduction into indoor cultivation facility

Photos by Shouhua Wang

Diseases Affecting Root

Ectoparasitic Nematodes



Tylenchorhynchus sp. from a hemp field

- Poor growth overall
- Many types of nematodes in soil
- May increase susceptibility to fungal infections
- Control
 - Test soil for nematodes before planting
 - Pre-planting treatment by a nematicide

Photos by Shouhua Wang

Systemic Diseases

Systemic Wilt Caused by *Fusarium oxysporium*



Early sign of infection: wilt



Internal sign: discoloration



Fusarium oxysporium

Photos by Shouhua Wang

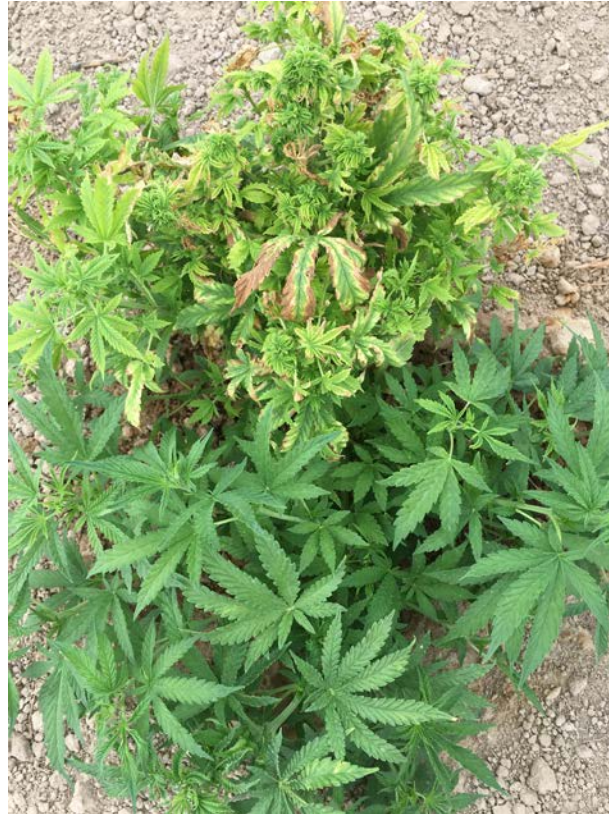
Systemic Diseases

Proliferation / Witches' Broom on Hemp

Infected
Plant ↓



Typical signs of symptoms include yellowing, stunting, proliferation, and other abnormal growth.



- Caused by Phytoplasma, a nonculturable bacterial that lives in the phloem sieve tubes of vascular tissue of live plants.
- Phytoplasma can be transmitted by leafhoppers, psyllids, and planthoppers.
- Control of insect vectors to mitigate disease spread.
- Remove symptomatic plants from fields ASAP.
- Keep mother or source plants free from phytoplasma infection.

Photos by Shouhua Wang

Systemic Diseases

Hemp Streak and Cannabis Cryptic Virus



- Interveinal chlorosis and leaf wrinkling
- No direct relationship between the symptom and presence of cryptic virus. (Eur J. Plant Pathology (2018) 150:575-588).
<http://dx.doi.org/10.1007/s10658-017-1301-y>
- Etiology may still not known.
- Genetic chimera or abiotic stress is suspected.
- Remove symptomatic plants from fields.

Photos by Shouhua Wang

Systemic Diseases

Mosaic and Hop Latent Viroid



- Mosaic or chlorosis.
- Positively detected in some symptomatic plants
- Etiology may still need to be investigated.
- Genetic chimera or abiotic stress may contribute to the symptom.
- Remove symptomatic plants from fields.

Photos by Shouhua Wang

Systemic Diseases

Hemp Leaf Roll and Beet Curly Top Virus



Leaf curling upwards

- Leaves thicken and roll upwards
- Beet curly top virus was detected from hemp plants
- Etiology may still need to be investigated.
- Genetic chimera or abiotic stress may contribute to the symptom.
- Remove symptomatic plants from fields.

Photos by Shouhua Wang

Holistic Diagnosis

A Case of Hemp Crop Failed Due to Collective Pathogens

- 75-80% crop loss
- Symptoms include dieback, stem rot, root rot, leaf wilt, and witches' broom
- 15 pathogens recovered including soil-borne fungi, oomycetes, and phytoplasma
- Extremely high population of fungus-feeding nematodes around root zone (rhizosphere)
- Hemp plants are susceptible to many pathogens present in the soil

Organism Identified	# of Sample Plants Infected	% of Sample Plants Infected
<i>Fusarium equiseti</i>	14	58.3%
<i>Pythium ultimum</i>	11	45.8%
<i>Fusarium oxysporium</i>	7	29.2%
<i>Rhizoctonia solani</i>	3	12.5%
<i>Candidatus Phytoplasma trifolii</i>	3	12.5%
<i>Pythium conidiophorum</i>	3	12.5%
<i>Fusarium solani</i>	3	12.5%
<i>Pythium salpingophorum</i>	2	8.3%
<i>Fusarium tricinctum</i>	2	8.3%
<i>Fusarium incarnatum</i>	1	4.2%
<i>Fusarium redolens</i>	1	4.2%
<i>Pythium heterothallicum</i>	1	4.2%
<i>Pythium perplexum</i>	1	4.2%
<i>Pythium arrhenomanes</i>	1	4.2%
<i>Fusarium proliferatum</i>	1	4.2%

Infection by Organisms	# of Sample Plants	% of Sample Plants
Single-organism infection	6	25.0%
Dual-organism infection	12	50.0%
Tri-organism infection	4	16.7%
Quad-organism infection	4	16.7%
Single <i>Fusarium</i> species infection	5	20.8%
Dual <i>Fusarium</i> species infection	1	4.2%
Single <i>Pythium</i> species infection	1	4.2%
Dual <i>Pythium</i> species infection	1	4.2%
Dual infection by <i>Fusarium</i> and <i>Pythium</i>	13	54.2%
Tri infection by <i>Fusarium</i> , <i>Pythium</i> and <i>Rhizoctonia</i>	3	12.9%

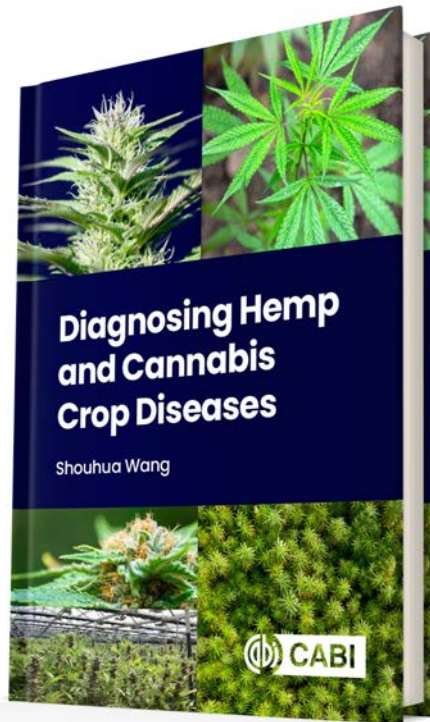
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Manage Cannabis Diseases

Summary

- New and highly regulated crop/industry
- Limited information available for cannabis crop diseases
- *Fusarium*, *Pythium*, phytoplasma, and viruses are major pathogens
- Powdery mildew and other mold diseases need immediate attention
- Nematodes such as root-knot nematodes can be a major issue for hemp production
- Other diseases such as foliar leaf spot are reported in some areas
- Very Limited chemical control options
- Prevention and sanitation is the key
- Accurate lab-based diagnosis is critical

For Complete Information



Diagnosing Hemp and Cannabis Crop Diseases

Shouhua Wang

October 2021

- **A field and laboratory guide to diagnosing hemp and cannabis diseases and pest problems**
- **Ready-to-adopt skills, methods and protocols in plant diagnosis, which can be applied to other crops**
- **Over 300 colour photographs accompanied by a wealth of disease information, including field observations, unique symptoms, microscopic details, and molecular data**

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