

# Industrial Hemp Crop Diseases

## What We've Seen and What We Know\*

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**\* This presentation contains 100% cannabis disease information obtained by the presenting author and the plant pathology team**

# Cannabis Crop Diseases



The King of the Rest

**\*Industrial hemp and marijuana are both classified by taxonomists as Cannabis sativa, a species with hundreds of varieties. C. sativa is a member of the mulberry family. Industrial hemp is bred to maximize fiber, seed and/or oil, while marijuana varieties seek to maximize THC (delta 9 tetrahydrocannabinol, the primary psychoactive ingredient in marijuana).**



Photos by Shouhua Wang

# Cannabis Crop Diseases



Powdery mildew

Botrytis blight

Mosaic (viral)

Stem canker (*Phytophthora*, *Pythium*)

Vascular wilt (*Fusarium*, *Verticillium*)

Root rot (Soil borne pathogens)

Nematode disease (root-knot, lesions, etc.)

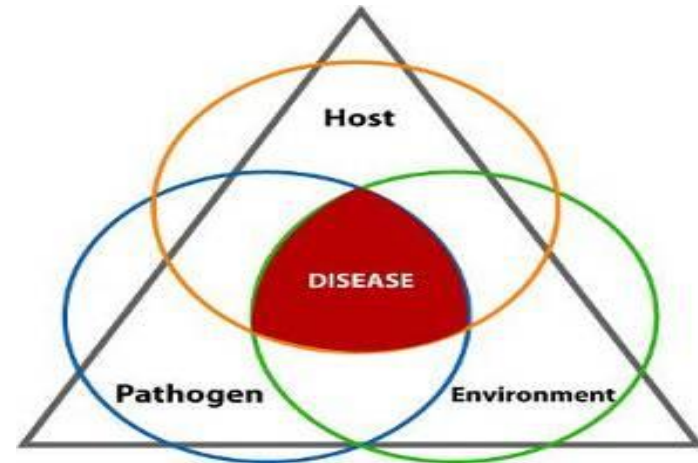
## Common Problems of Cannabis Plants

Photos by Shouhua Wang

# Cannabis Crop Diseases

**A plant disease is a result of interaction of three factors:**

- **Host** - A susceptible host plant is available
- **Pathogen** - A pathogen is present
- **Environment** - Environmental conditions that favour the host and pathogen to allow disease development



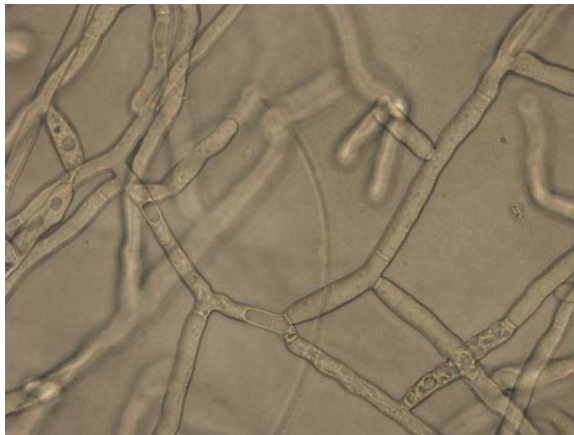
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**Plant Disease Triangle**

# Cannabis Crop Diseases

## Fungi and Diseases They Cause

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



Rhizoctonia from hemp root



Fusarium spores from Marijuana



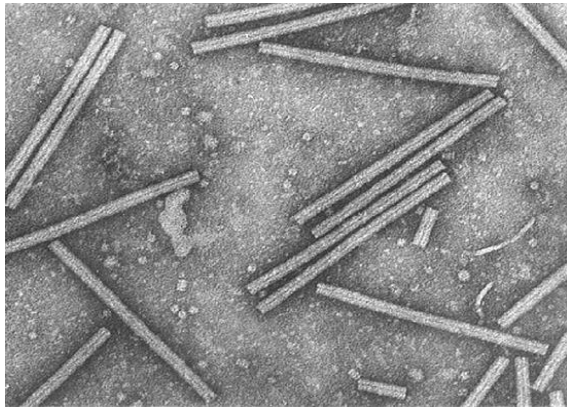
Hemp stem/root rot

Photos by Shouhua Wang

# Cannabis Crop Diseases

## Viruses and Diseases They Cause

- Viruses are infectious, intracellular pathogens that are submicroscopic particles composed of protein and nucleic acid.
- 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 symptom

Photos by Shouhua Wang

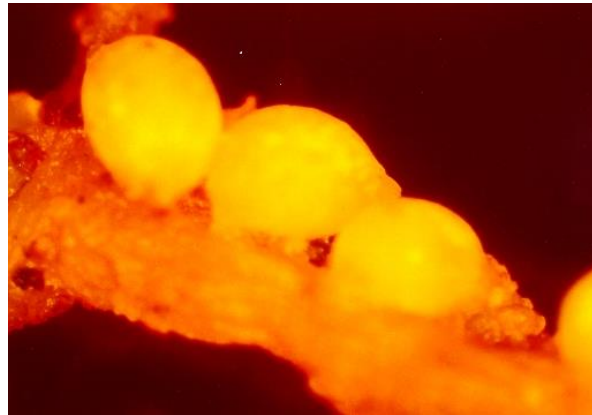
# Cannabis Crop Diseases

## Nematodes and Diseases They Cause

- 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
- Estimated cost of damage to crops worldwide approaches \$100 billion



Root-knot nematode



Cyst nematode



Lesion nematode

Photos by Shouhua Wang

# Cannabis Crop Diseases

## Bacteria and Diseases They Cause

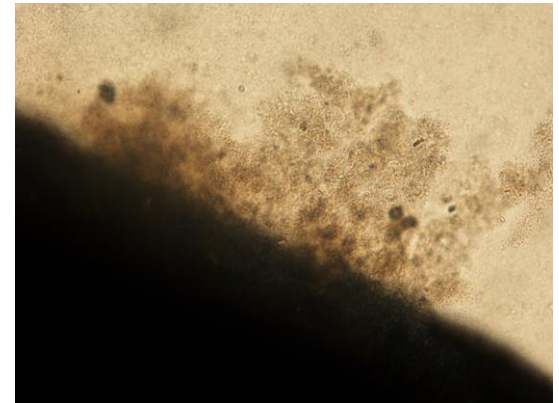
- Microscopic single-celled organisms
- Most plant pathogenic bacteria are bacilliform (rod-shaped)
- Include fastidious prokaryotes – phytoplasmas and spiroplasmas
- Diseases: soft rot, fire blight, leaf spot/speck, wilt, root rot



Onion soft rot



Tomato bacterial speck

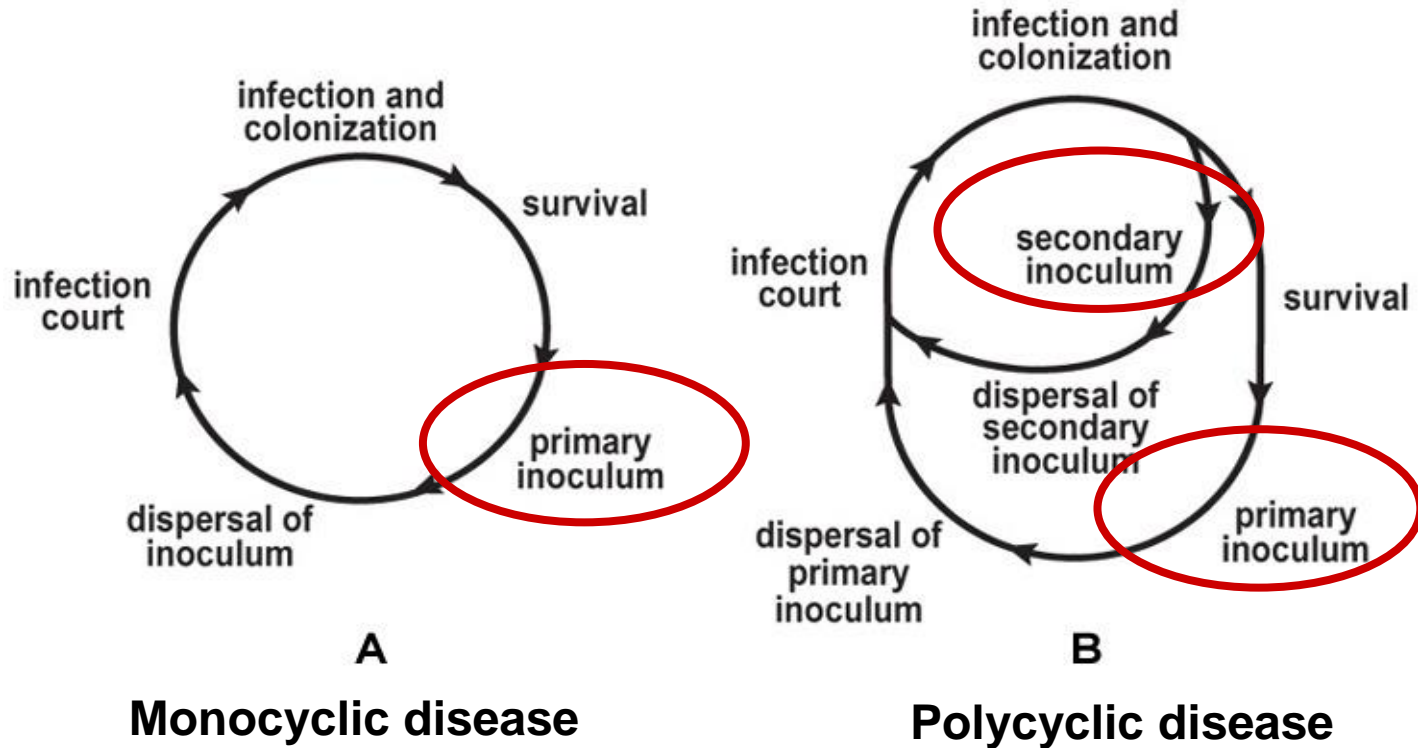


Bacterial streaming

Photos by Shouhua Wang



# Cannabis Crop Diseases



## Disease Cycles and Implications for Control Strategies

Courtesy of R. Hoenisch

# Cannabis Crop Diseases

## Grown in an Open Field



### Diseases to watch for

- Mosaic viruses
- Wilting
- Stem canker
- Root rot
- Nematodes
- Abiotic diseases

Photos by Shouhua Wang

# Cannabis Crop Diseases

## Clues That a Disease Is Abiotic

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- Symptoms appear suddenly.
- Symptoms on individual plants are fairly uniform.
- Symptoms develop on several parts of individual plants or on many plants.
- Different plant species in the area have similar symptoms.
- Symptoms may follow a chemical application pattern in lines or rows.
- Foliar lesions have a distinct line between healthy and affected tissue.
- Biotic signs are not present (unless the affected plant has been invaded by secondary pathogens or saprophytes)

# Cannabis Crop Diseases

## Effects of Light on Marijuana Plant Growth



Over growth of stem

**Physiological and growth response to light: Stem enlargement**  
Move into long light for flower stage production too early

Photos by Shouhua Wang

# Cannabis Crop Diseases

## Iron, Zinc and Manganese Deficiency



Symptom of nutrient deficiency in Marijuana plants

Photos by Shouhua Wang

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## Herbicide Damage



Photos by Shouhua Wang

# Cannabis Crop Diseases

## Chemical Injury



Photos by Shouhua Wang

# Cannabis Crop Diseases

## Drought Injury



Photos by Shouhua Wang



# Cannabis Crop Diseases



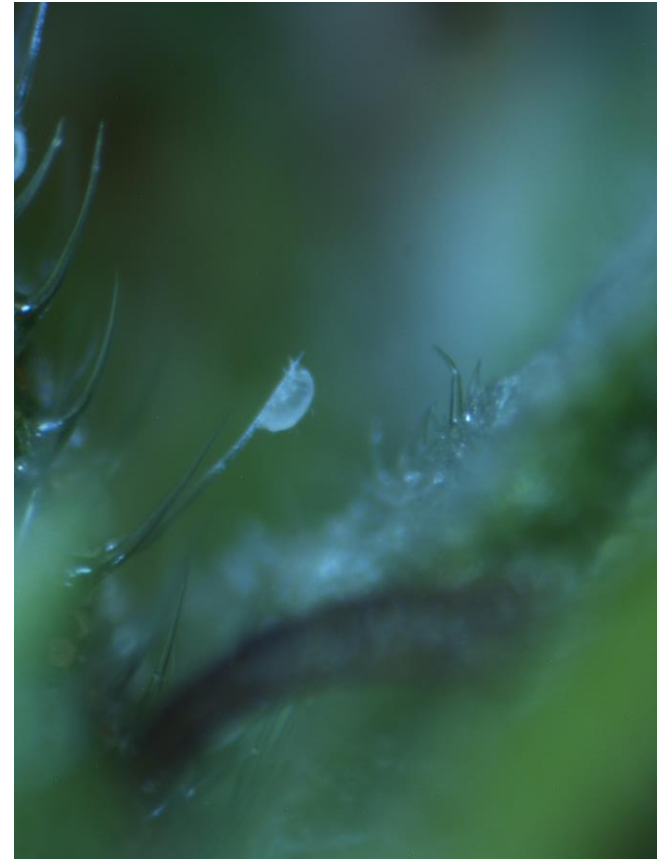
## Aphid Damage



Photos by Shouhua Wang

# Cannabis Crop Diseases

## Mite Damage



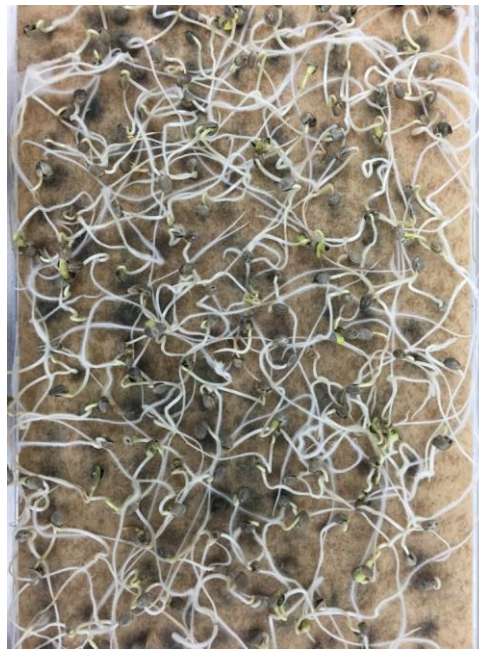
Photos by Shouhua Wang

# Cannabis Crop Diseases

**Seed treatment to eliminate seed-borne diseases  
-Damping off or seedling death**



**Surface-sterilized hemp seeds**



**Untreated imported hemp seeds**



***Alternaria* from hemp seeds**

**Photos by Shouhua Wang**

# Cannabis Crop Diseases

## Vascular Wilt (*Fusarium oxysporium*)

- Systemically infected
- Wilting and eventually death of plants
- Pathogen survives in soil and infected plant materials
- Can come from mother plants
- Eradicate disease, change soil or grow hemp in a different field



Photos by Shouhua Wang

# Cannabis Crop Diseases

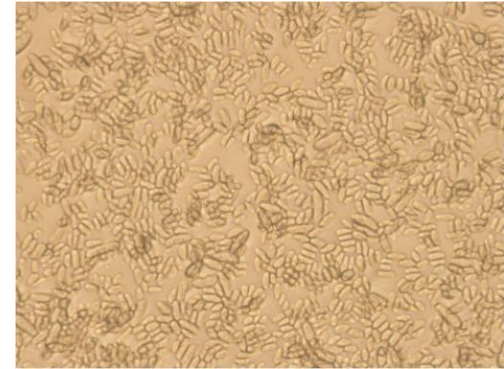
Two *Fusarium* Species Cause Vascular Wilt on Marijuana Plants



Internal symptom



*F. oxysporium*



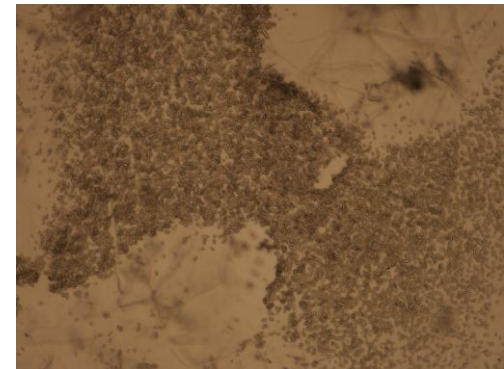
Microconidia



Plating on medium



*F. solani*



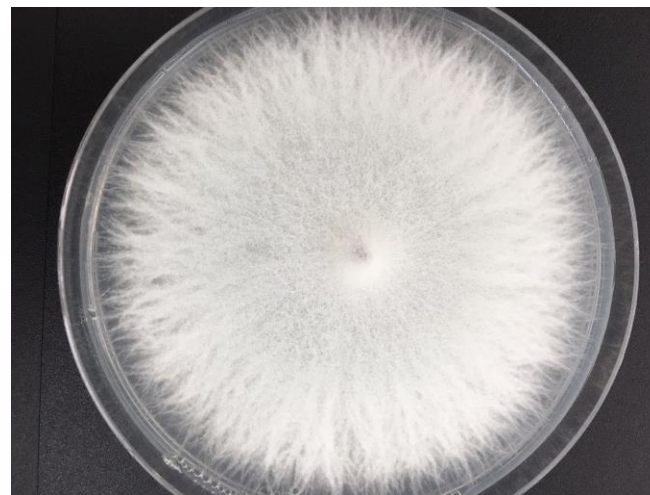
Microconidia

Photos by Shouhua Wang

# Cannabis Crop Diseases



**Vascular wilt of hemp  
caused by *Fusarium  
oxysporium***



**Photos by Shouhua Wang**

# Cannabis Crop Diseases



**Hemp Leaf Mosaic and Distortion**



**Photos by Shouhua Wang**

# Cannabis Crop Diseases



Hemp Leaf Roll Virus?

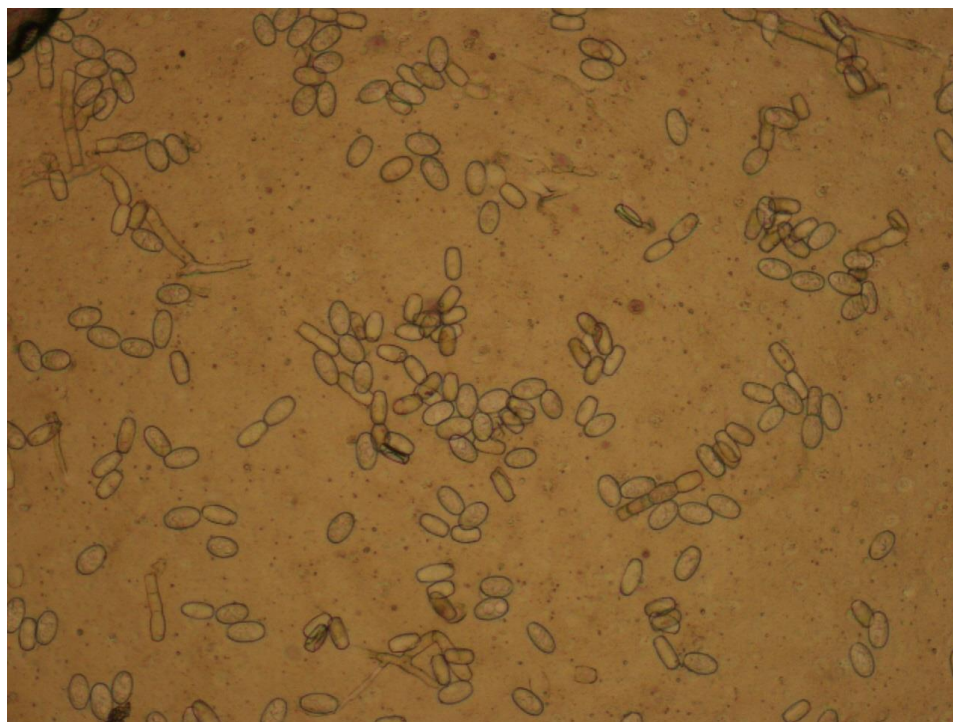
Photos by Shouhua Wang



# Cannabis Crop Diseases



**Powdery Mildew on Cannabis Plants**



***Golovinomyces ambrosiae***

**Photos by Shouhua Wang**

# Cannabis Crop Diseases

## Stem Canker – Mainly Caused by *Phytophthora*



Verbena stem canker

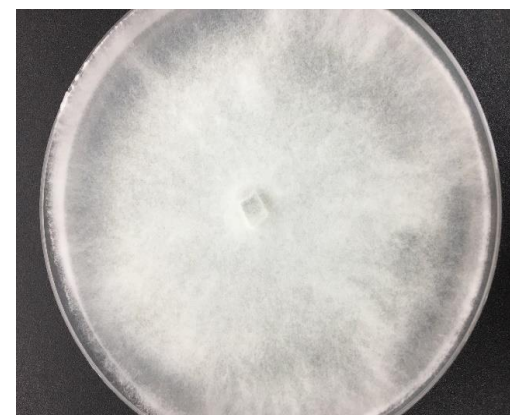


Hemp basal stem canker

Photos by Shouhua Wang

# Cannabis Crop Diseases

## *Pythium* Crown Rot of Industrial Hemp



*Pythium  
aphanidermatum*

Photos by Shouhua Wang

# Cannabis Crop Diseases

## Root Rot –Caused by Soil Borne Pathogens



Healthy hemp root ball



Diseased hemp root (rot)

Photos by Shouhua Wang

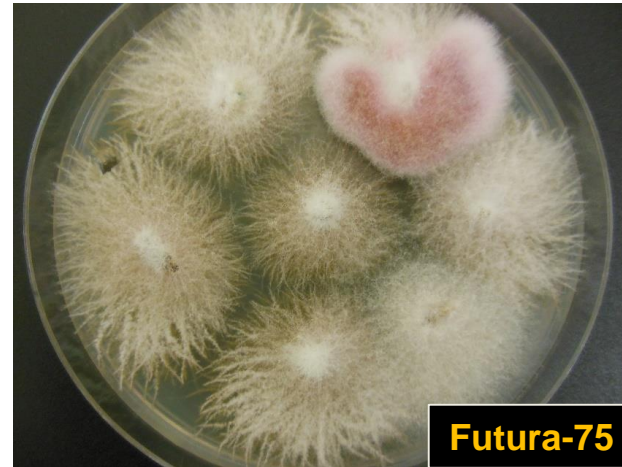
# Cannabis Crop Diseases

## *Fusarium* Root Rot of Industrial Hemp



Photos by Shouhua Wang

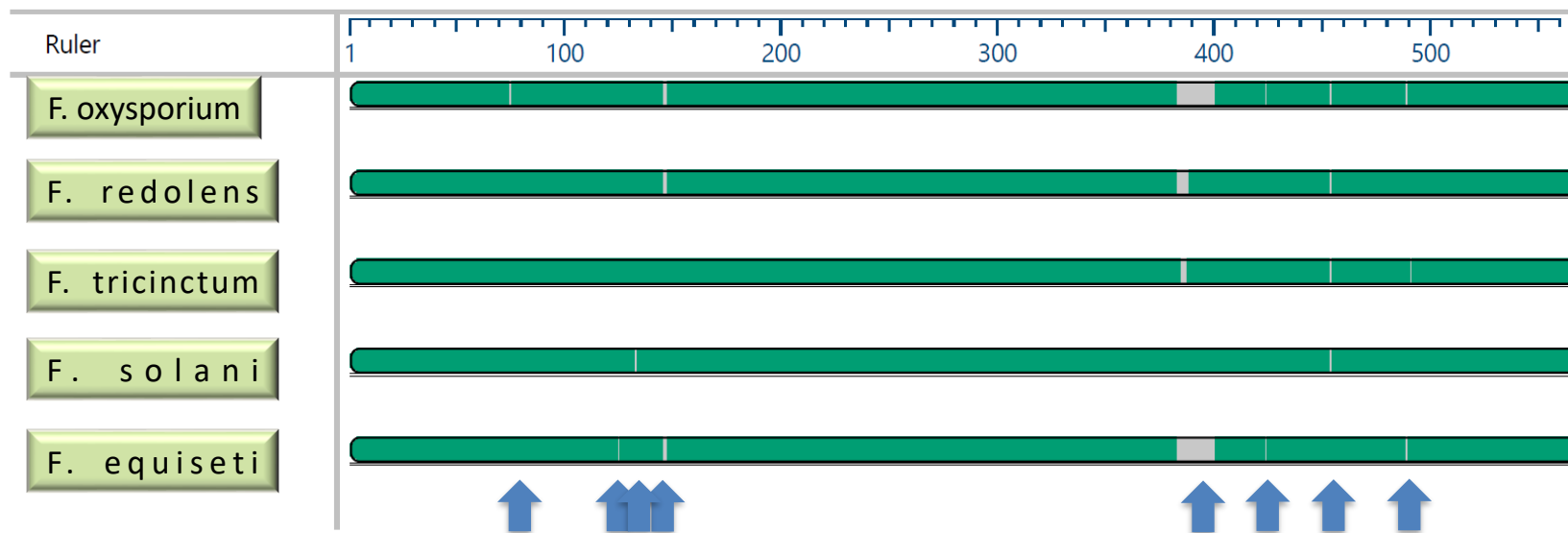
# Cannabis Crop Diseases



Photos by Shouhua Wang

# Cannabis Crop Diseases

## DNA Barcode-Based Identification



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# Cannabis Crop Diseases

*Fusarium oxysporium*



*Fusarium solani*

*Fusarium redolens*

*Fusarium tricinatum*

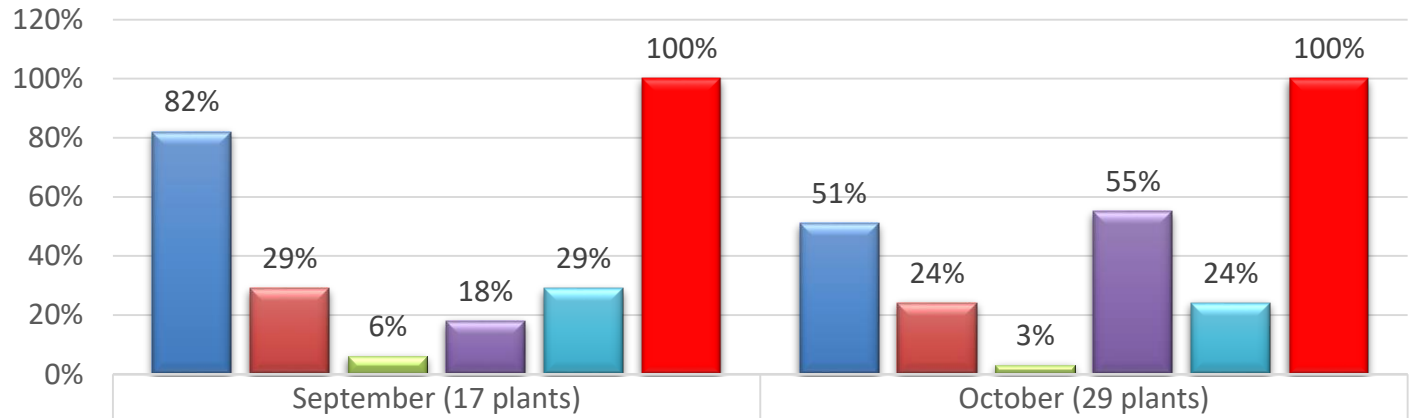
*Fusarium equiseti*

Photos by Shouhua Wang



# Cannabis Crop Diseases

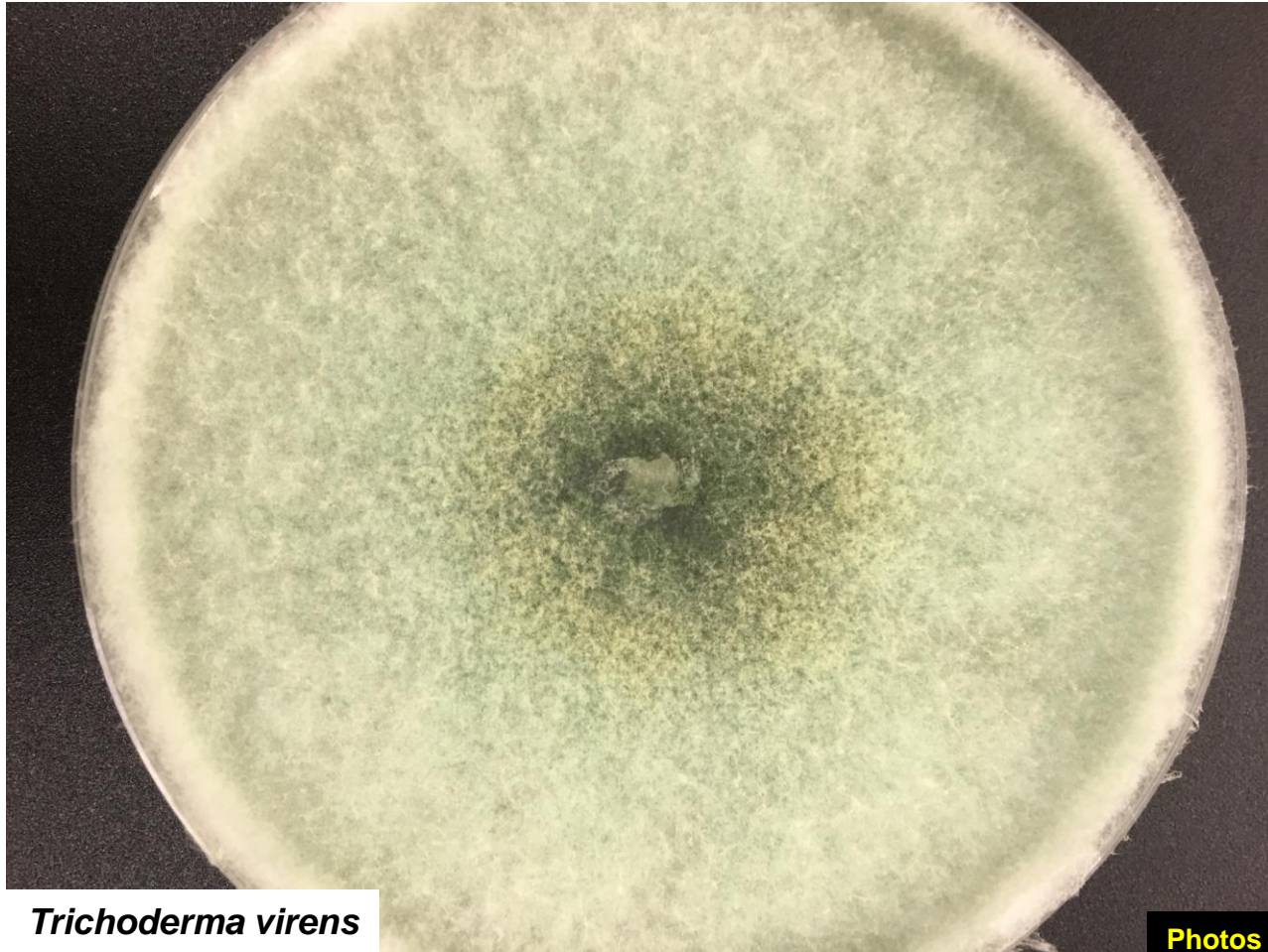
## Frequency of *Fusarium* Isolated From Roots



	September (17 plants)	October (29 plants)
<i>F. oxysporum</i>	82%	51%
<i>F. solani</i>	29%	24%
<i>F. redolens</i>	6%	3%
<i>F. Tricinatum</i>	18%	55%
<i>F. equiseti</i>	29%	24%
Total Fusarium Infection	100%	100%

■ *F. oxysporum*  
 ■ *F. solani*  
 ■ *F. redolens*  
 ■ *F. Tricinatum*  
 ■ *F. equiseti*  
 ■ Total Fusarium Infection

# Cannabis Crop Diseases



*Trichoderma virens*

Photos by Shouhua Wang

# Cannabis Crop Diseases

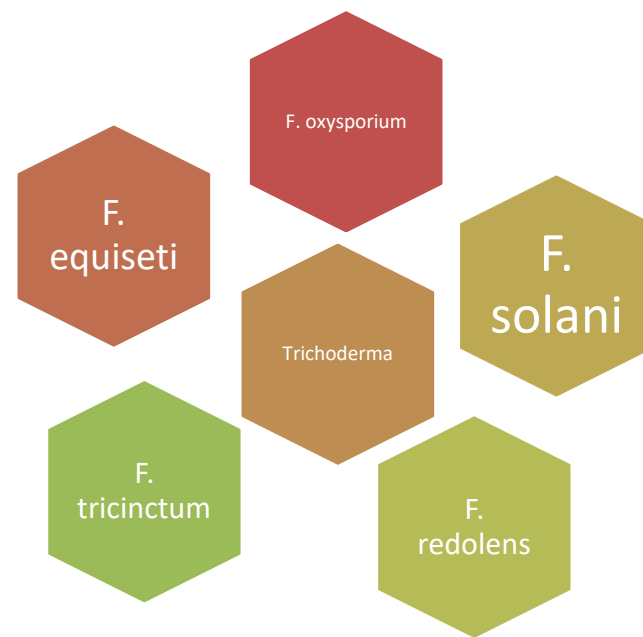
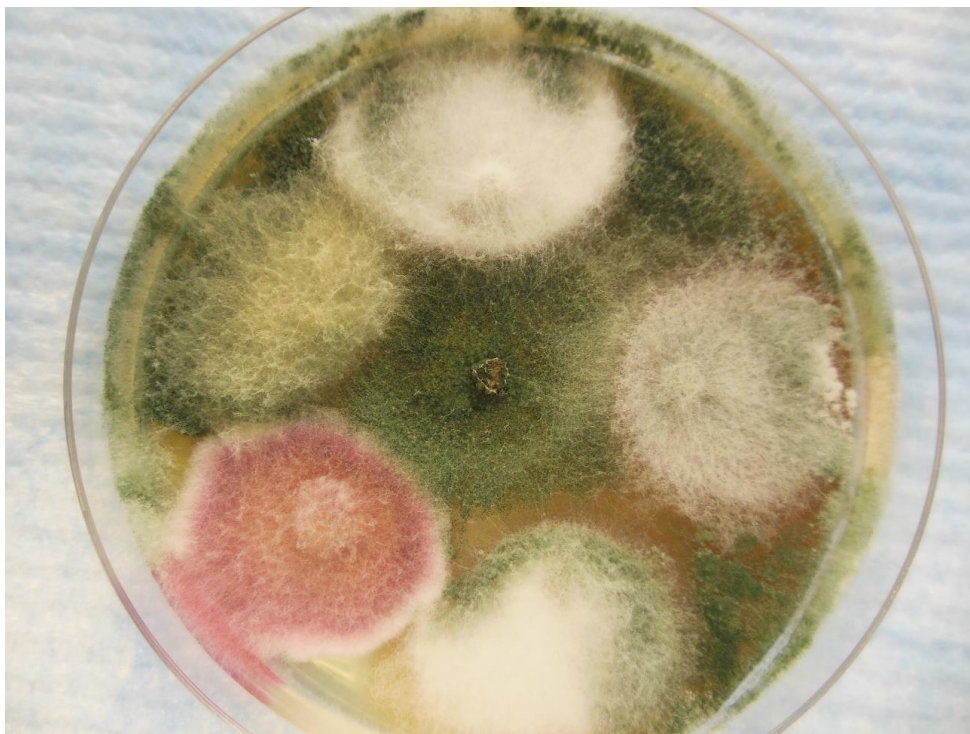
## *Trichoderma virens* – CsR-34

- **General Traits of *Trichoderma virens***
  - Haploid filamentous hyphomycete (fungi)
  - Protect many crops from a variety of pathogens
  - Parasitize on pathogenic fungi and antibiosis
  - Induce host plant resistance
  - Increase tolerance to stress by promoting plant growth
  - Produce novel secondary metabolites for pharmaceutical and agricultural uses
  - Degrade hazardous compounds such as pesticides and sequester heavy metals
  - Colonize on roots epidermal cells

- **Potentials of CsR-34 Isolate**
  - Isolated from the hemp root so it may be Cannabis-specific or more use-friendly in hemp crops
  - Associated with *Fusarium* pathogens so it may be more effective on controlling *Fusarium* diseases
  - Originated from irrigated agricultural system so it may have more power to combat desert environment as a bioaugmentation agent
  - Produced in large scale easily so it can be used in both Marijuana growing facilities and open hemp fields

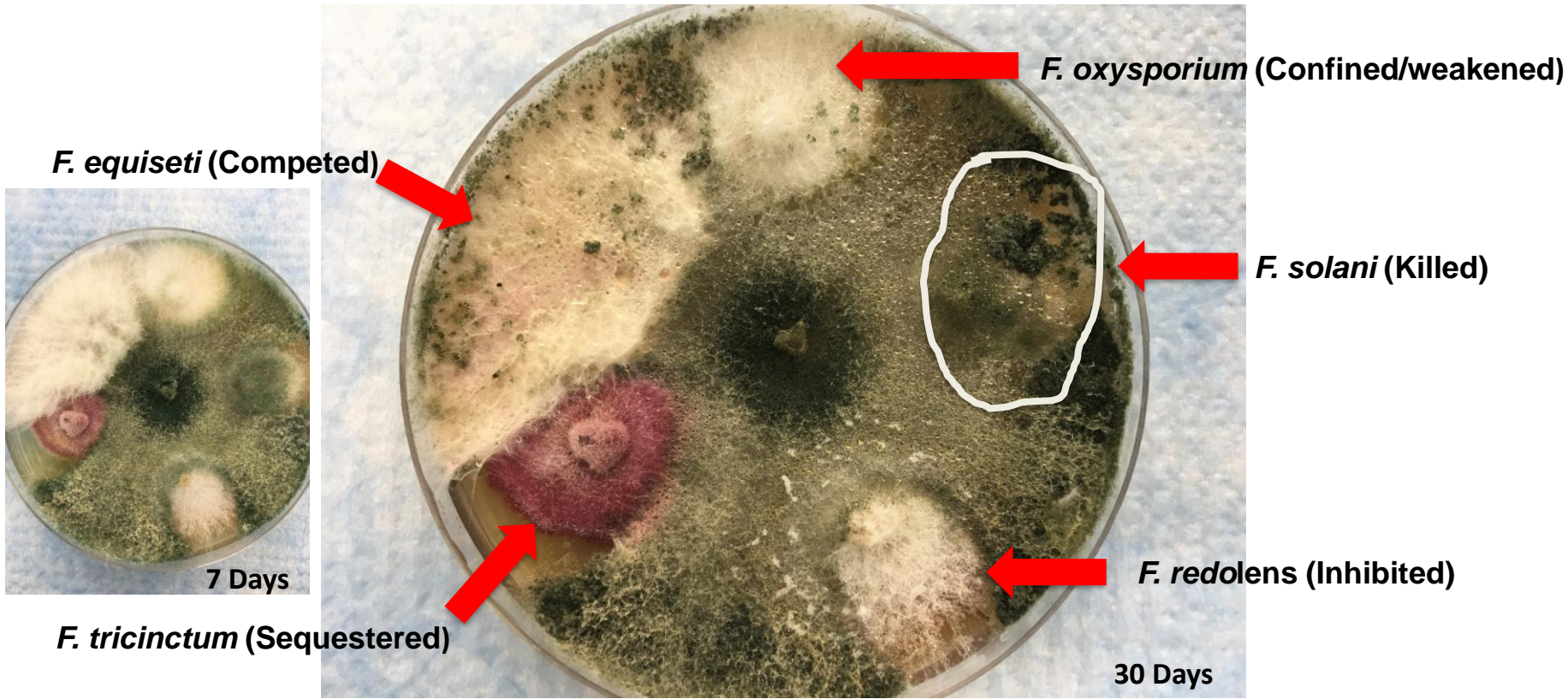
# Cannabis Crop Diseases

## Antagonistic Effect of *T. virens* – CsR-34



Photos by Shouhua Wang

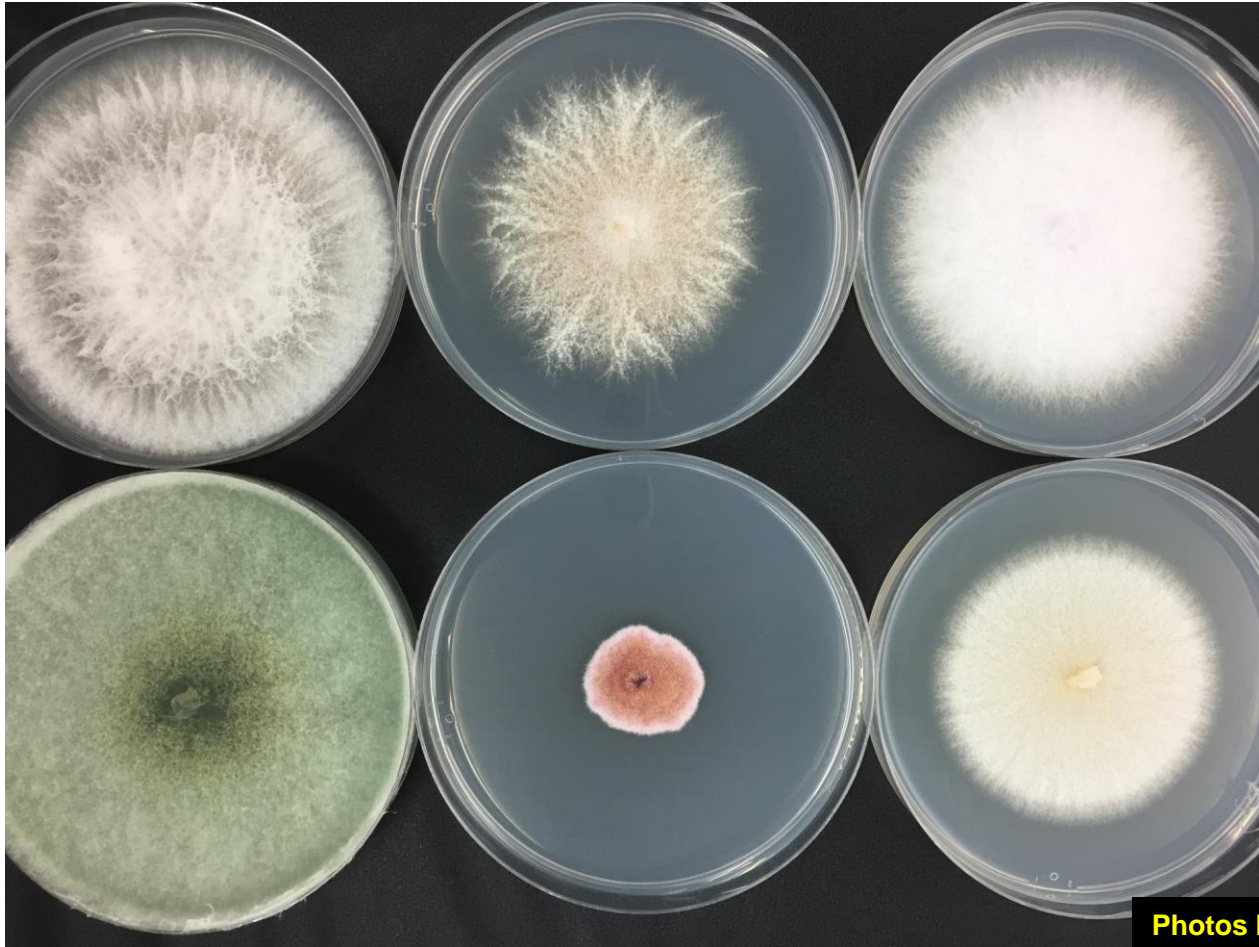
# Cannabis Crop Diseases



Inoculated on 12/15/16, pictured on 1/14/17

Photos by Shouhua Wang

# Cannabis Crop Diseases



Photos by Shouhua Wang

# Cannabis Crop Diseases

## Six Fungi Associated with Hemp Roots

Organism	Impact on Plant Health	Function Type
<i>F. oxysporium</i>	Root rot, wilt	Pathogen (Lead)
<i>F. solani</i>	Root rot	Pathogen (2 <sup>nd</sup> primary)
<i>F. redolens</i>	Root rot	Pathogen (3 <sup>rd</sup> primary)
<i>F. tricinctum</i>	Root rot	Weak pathogen
<i>F. Equiseti</i>	Root colonizer	Secondary pathogen
<i>Trichoderma virens</i>	Beneficial	Biocontrol agent



Hey, I found hemp, let's kill it!

I am good at it, let's do it!

I will help too!

I will take advantage of your guys' efforts

I'll come after you guys kill it

You guys are bad, let me stop you!

# Cannabis Crop Diseases

## Before-Planting Check

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- **Check seed health and sources**
- **Know what are in the soil: pathogens and nematodes**
  - **History of previous crops**
  - **History of disease incidence in previous crops**
  - **Get soil-borne pathogens tested by NDA Plant Pathology Lab**
    - **Fusarium (root rot, wilt)**
    - **Verticillium (wilt)**
    - **Phytophthora (root and crown rot, stem canker, etc.)**
    - **All nematodes (damage to root and induce fungal or bacterial infection)**



# Cannabis Crop Diseases

## Pre-planting Screening Tests

- **Lesion nematode test only**                      **\$20/sample**
- **All nematode panel analysis**                      **\$30/sample**
- **Fusarium oxysporium test only**                      **\$50/sample**
- **All Fusarium species analysis**                      **\$100/sample**

