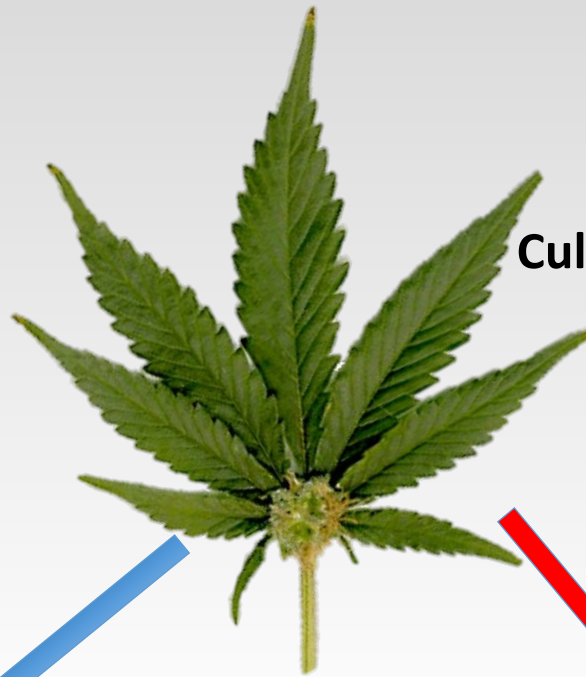


# Hemp Pathology Title

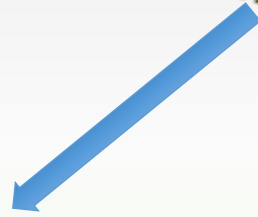
# *Cannabis sativa* in production



Cultivated for over 4,500 years

<0.3% THC

>0.3% THC



## Hemp

Agricultural  
Production



Food/Feed

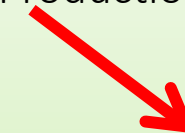
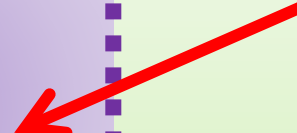
Oil

Fiber

## Agronomic

## Marijuana

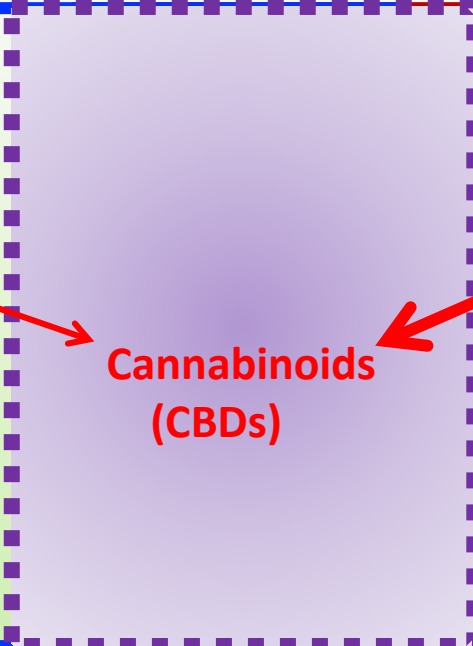
Glasshouse  
Production



Cannabinoids  
(CBDs)

THC

## Pharmacological



# Agronomic production



- I left this blank...because every state is different. Sorry. Just giving you pics to use or laugh at
- Most of our work is agronomic...So we are looking at Cannabis grown on 100-1000 acres; this year we will look at more 'veggie-like plantings'. No GH except Koch's postulates

**Table 1. State-Level Licensed Hemp Acreage, 2017–2019**

State	2017	2018	2019 <sup>a</sup>
Colorado	12,042	21,578	80,000
Kentucky	12,800	16,100	58,000
Oregon	3,500	7,808	51,313
Montana	542	22,000	40,000
Tennessee	718	3,338	37,416
Wisconsin	0	1,850	16,100
North Carolina	1,930	3,184	11,572
Nevada	490	1,881	9,145
New York	2,000	2,240	5,000
North Dakota	3,100	2,778	2,175
Total	37,122	82,757	310,721





# Pharmacological





# Producing for Cannabinoids

- Yield ½ lb to 2 lb of dry material per plant
- ~\$1.50 per % point CBD/lb
- Example of price breakdown:
  - Average yield of one pound of floral material
  - Price/percentage/lb
- \$1.50/percentage/lb @ 10% CBD makes that plant worth \$15
  - At 1500 plants/ac you have \$22,500
  - Have not heard of single person in 2019 making this amount!
- Price for CBD has decreased since spring
- Remember labor costs: e.g., 10 acres requires 7-8 workers taking 4 weeks at 8 hr/day

“Never underestimate the ability of the American farmer to undermine their own price constructs.” John Baugh



U.S. Region Products	Units	Assessed Price
CBD Biomass (0-25k pounds)	\$ / %CBD / pound	\$1.81
CBD Biomass (25k-100k pounds)	\$ / %CBD / pound	\$1.79
CBD Biomass (100k-1M pounds)	\$ / %CBD / pound	\$1.73
CBD Biomass (1M+ pounds)	\$ / %CBD / pound	\$1.40
CBG Biomass	\$ / %CBD / pound	\$21.36
CBD Flower (Bulk)	\$ / pound	\$274
Clones	\$ each	\$4.44
Industrial Seeds	\$ / pound	\$4.57
CBD Seeds (Non-Feminized)	\$ / pound	\$2,360
CBD Seeds (Feminized)	\$ each	\$1.00
Crude Hemp Oil	\$ / kilo	\$936
Refined Hemp Oil	\$ / kilo	\$3,380
Distillate - THC Free	\$ / kilo	\$3,962
Distillate - Broad Spectrum	\$ / kilo	\$3,415
Distillate - Full Spectrum	\$ / kilo	\$2,920
CBD Isolate	\$ / kilo	\$2,437

## Hemp Benchmarks Reports

- Spot index reports November and December

U.S. Region Products	Units	Assessed Price
CBD Biomass (0 - 25K pounds)	\$ / % CBD / pound	\$1.73
CBD Biomass (25K - 100K pounds)	\$ / % CBD / pound	\$1.47
CBD Biomass (100K - 1M pounds)	\$ / % CBD / pound	\$1.45
CBD Biomass (1M+ pounds)	\$ / % CBD / pound	\$1.17
CBG Biomass	\$ / % CBG / pound	\$20.29
CBD Flower (Bulk)	\$ / pound	\$221
Clones	\$ / each	\$3.53
Industrial Seeds	\$ / pound	\$4.38
CBD Seeds (Non-Feminized)	\$ / pound	\$1,967
CBD Seeds (Feminized)	\$ / seed	\$0.88
Crude Hemp Oil	\$ / kilogram	\$890
Refined Hemp Oil (Aggregate)	\$ / kilogram	\$3,051
Distillate - THC Free	\$ / kilogram	\$3,677
Distillate - Broad Spectrum	\$ / kilogram	\$3,073
Distillate - Full Spectrum	\$ / kilogram	\$2,445
CBD Isolate	\$ / kilogram	\$2,218



# Key Issues facing Industrial Hemp Production

1. Legal Climate
2. Contracts
3. Seed Availability
4. Seed Quality?
- ...5. Disease



Title: Stack of hemp grown on George Erickson's farm near Seneca, Illinois **“He was induced to raise this crop on promise of a market for it. It is now rotting”**

Contributor Names: Lee, Russell, 1903-1986, photographer Created / Published 1937 Jan.

# Legal....

- Legal in NY





# 2. Hemp and Contracts

- A contract is a binding legal agreement voluntarily entered into by two or more parties.
- Contracts govern 36 percent of the value of U.S. agricultural production
  - up from 28 percent in 1991
  - 12 percent in 1969.
- Farmers have long used formal contracts in obtaining land, credit, and equipment, as well as in organizing the production and marketing of commodities
- Contracts provide a price signal about the future value of the commodity
  - Fiber quality
  - Oil content
  - Oil quality
  - Seed size
- Provide traceability
  - pressures will mount to ensure traceability of products for health and consumer concerns
- Contracting is closely associated with farm size



# Seed Availability

Favorite shop



items



100Pcs Hemp Seed,Hemp Semen,Plant Semen cannabi,High germination rate,

\$7.99+

Ask a question

Package size

Select an option

Quantity

1

Add to cart



Other people want this. Over 20 people have this in their carts right now.

## Overview

- Handmade item
- Craft type: Gardening
- Seed type: Herb
- Organic: No
- Materials: Bonsai, Outdoor Plants, Bonsai seeds, Home Garden, Constipation, Hemp seeds, Hemp Semen, Plant Semen cannabi





# Economic Impact

- The profitability potential is real
- Seed Yield-300-1200 lbs. per acre
- \$~1.10 per pound (2019)
  - \$40-55 per bushel!
- ~40 gallons of oil/acre
- Per acre: 5,300 pounds of straw, which can be transformed into approximately 1,300 pounds of fiber per acre
- Fiber price \$0.10 per pound ~\$130 per ton
- Methods for processing the fiber, specifically separating the core/curds from the fiber is considerably more difficult.
  - So are the obstacles to development



# Issue 4: Poor seed quality

“Bad seed is a robbery of the worst kind: for your pocketbook not only suffers by it, but your preparations are lost and a season passes away unimproved.” George Washington

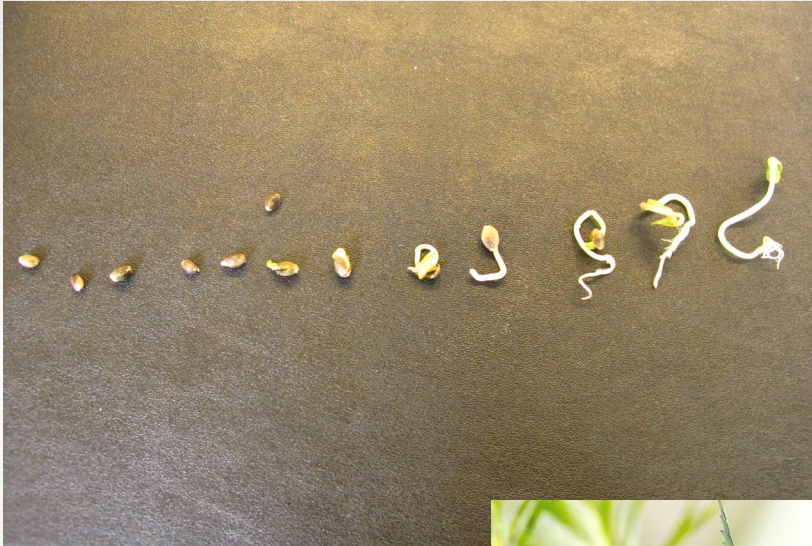
## Hemp varieties planted in 2016 at Throckmorton-Purdue Agricultural Center (TPAC)

Cultivar	Source	Type	Primary purpose	Germination (%)
Canda			Grain	89.0 ± 3.6
Delores			Grain	87.3 ± 2.2
Joey			Grain	53.3 ± 4.7
CFX-1			Dual	74.3 ± 6.8
CFX-2			Grain	85.0 ± 3.1
CRS-1			Grain	81.7 ± 3.5
X-59			Grain	92.3 ± 2.7
Felina 32			Fiber	81.3 ± 1.2
Futura 75			Fiber	86.3 ± 4.3
Carmagnola			Fiber	40.3 ± 1.8





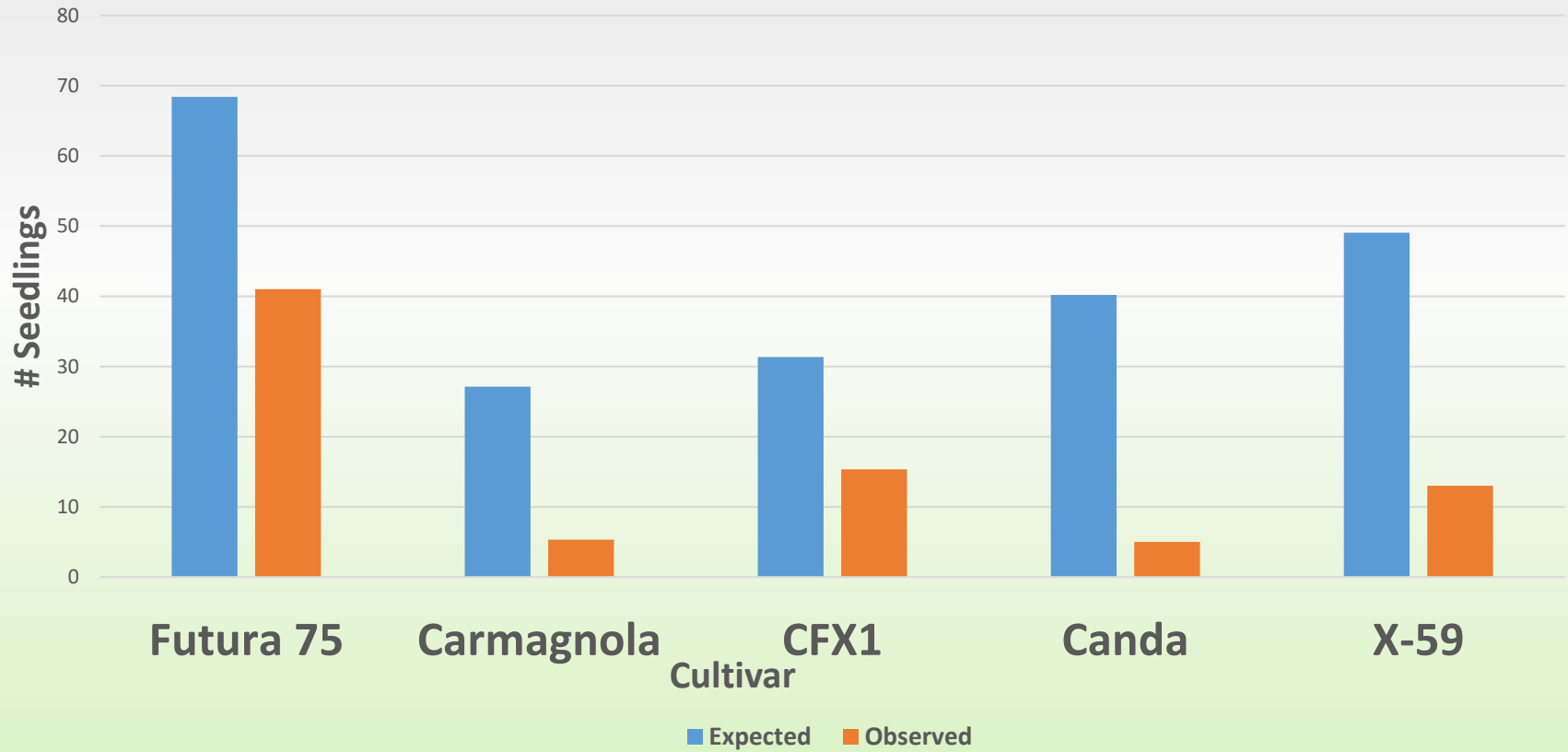
# Seed germination issues are even worse in the field!



Birds love it, especially goldfinch and modos!

# Percent Germination versus Stand Density

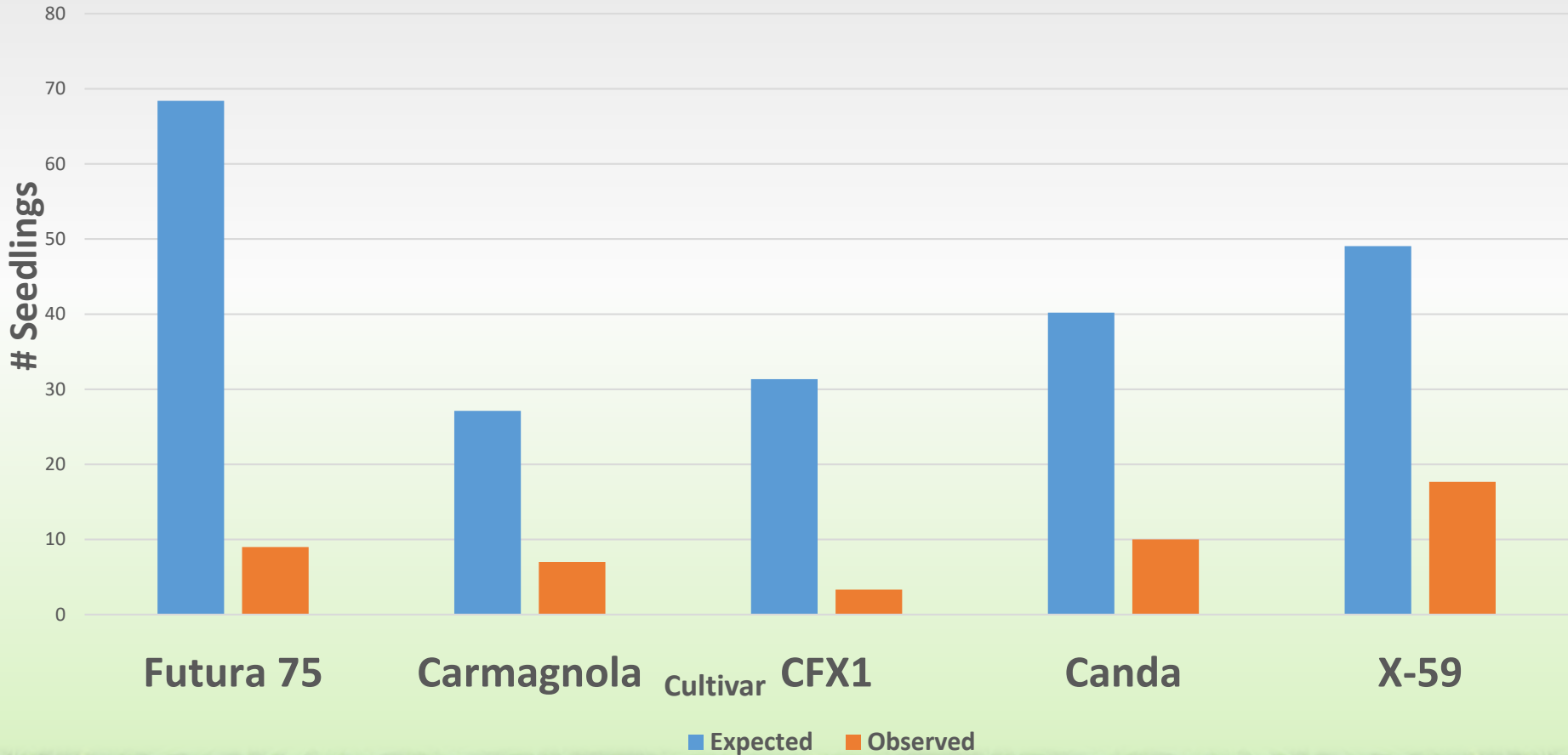
June 2nd Stand: Average Stand Count Sampling, Taken on 6/9/17





# Percent Germination versus Stand Density

June 13th Stand: Average Stand Count Sampling, Taken on 6/20/17



# Selecting Seeds

- Want to choose a reputable seller
  - but how?
- Talk to current hemp farmers
- Make sure they have proper seed labels
- Look at how varieties performed in 2019 (hot or not)

*Office of Indiana State Chemist and Seed Commissioner  
2019 Total THC Test Results by Hemp Variety*

*\*\*\*OISC does not recommend varieties, this document is the result of testing in 2019.*

Variety	Tested x	Total THC GC	Total THC UPLC	Acres Tested (rounded)	% of tests hot	Ratio
Abacus	2	0.375	0.504	7.5	50%	1 out of 2
Autopilot	3	0.224		15		
Awesome Blossom	1	0.51	0.577	0.05	100%	1 out of 1
Blue Genius	1	0.284		0.02		
Blue Haze	4	0.128		91		
Blue Mammoth	2	0.125		90		
Boax	6	0.2		48		
Bubby Remedy	3	0.578	0.544	12	100%	3 out of 3
CBDRX Cherry	2	0.421	0.489	16	50%	1 out of 2
Chard Cherry	1	0.204		45		
Cherry	4	0.238		50		
Cherry #5	4	0.339	0.501	4	25%	1 out of 4
Cherry Abacus	1	0.31		0.1		
Cherry Blossom	8	0.186		5		
Cherry Bubblegum	2	0.187		67		
Cherry Cherry	1	0.386		1		
Cherry Citrus	1	0.116		0.3		
Cherry DC	1	0.907	0.801	1		1 out of 1
Cherry Diesel	1	0.359		0.3		
Cherry Uno	5	0.265		24		
Cherry Wine	12	0.301	0.65	151	17%	2 out of 12





A photograph of soil in an organic farming system. The soil is dark brown and appears loose and crumbly. There are several small, green seedlings with two leaves each, growing from the soil. Some dry straw or plant matter is scattered on the surface.

## Organic

Hemp, soybeans, and other 'dicots' are more prone to poor stand establishment than corn or wheat

the seedling must pull the cotyledon seed leaves through the ground to emerge.

A photograph of soil in a conventional farming system. The soil is dark brown but is heavily clumped and crumbly, forming large, irregular blocks. A single small green seedling is visible, struggling to emerge from the soil.

## Conventional



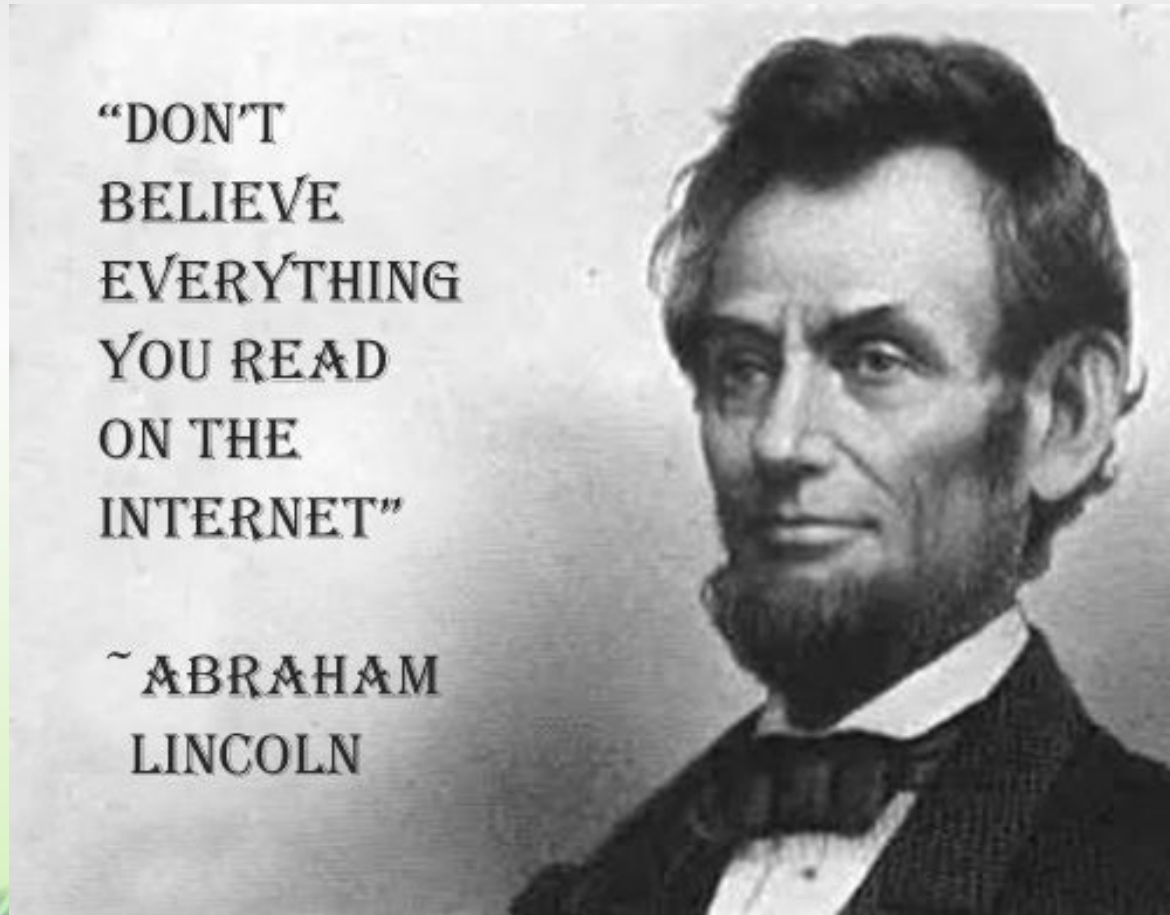
# Crusting

- Soil crusting delays or prevents seedling emergence.
- Hemp hypocotyls become swollen and/or break when trying to push through the crust.
- If the hypocotyl breaks, the seedling usually dies.
- Fields with fine-textured soils, low organic matter, and little surface residue can be vulnerable to crusting, especially where excessive tillage has taken place.





“Cannabis is highly disease resistant.”



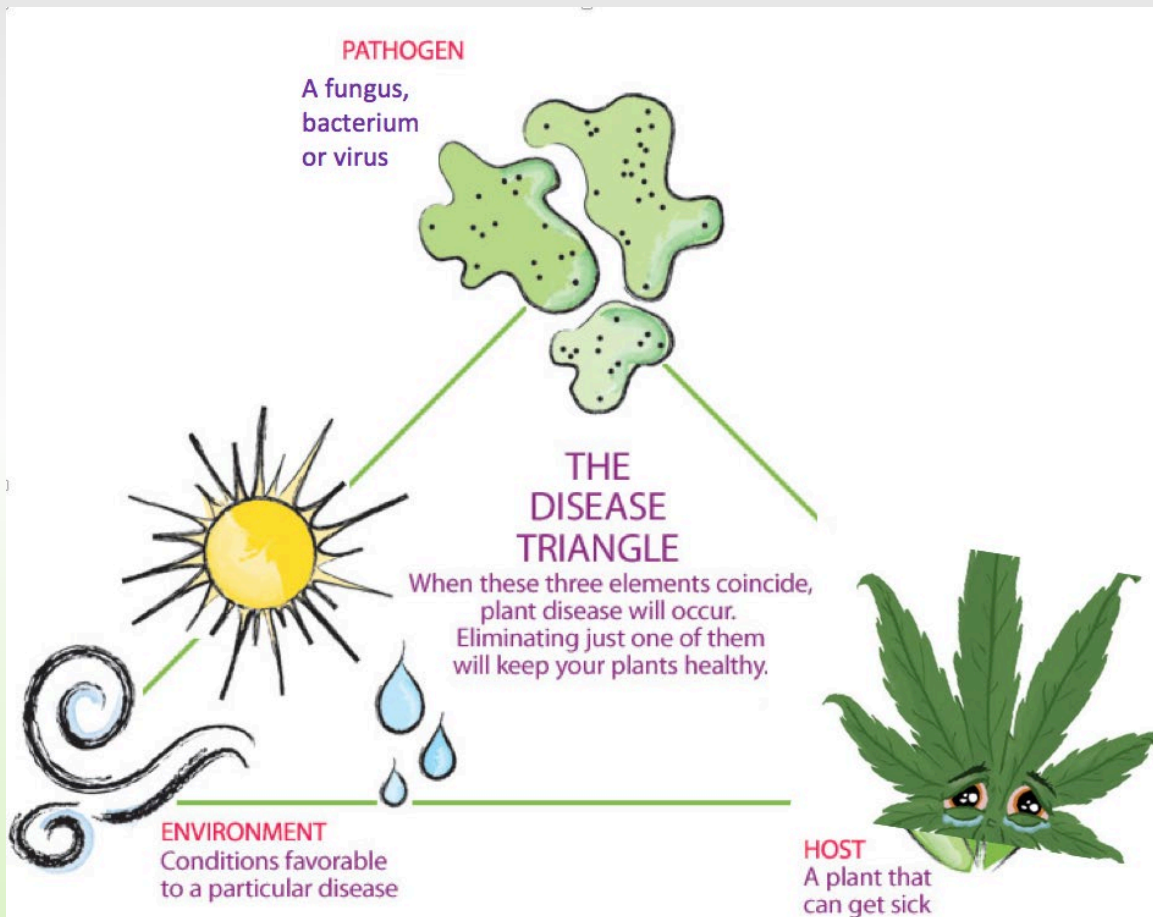
# Hemp and Disease



Photo by Chelsi Abbott



At least 88 species of fungi and pseudofungi attack *Cannabis* and more are being discovered every year.







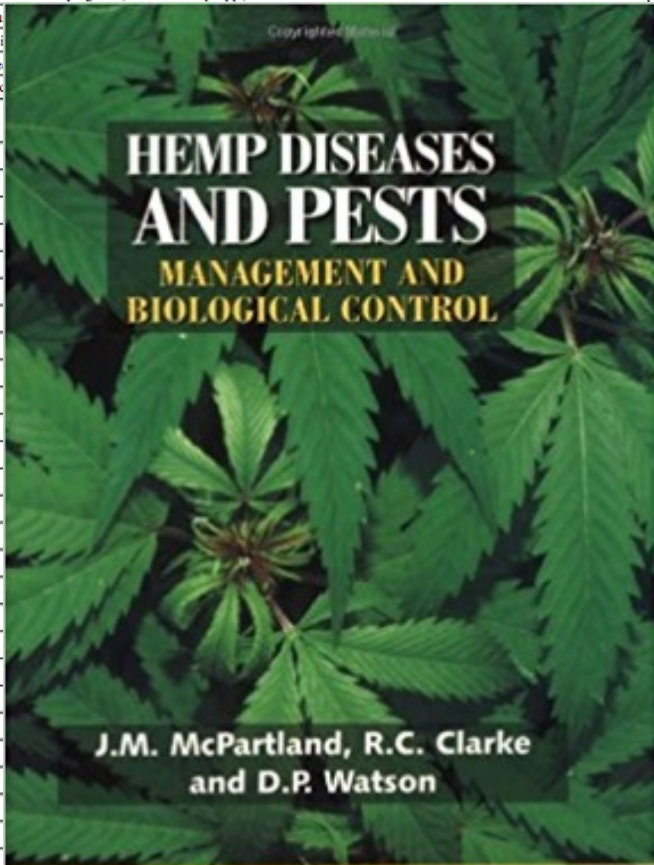


# Spoiler Alert: Hemp is not disease resistant.

Sample #	List of Diagnosis/ID(s)
15-00536	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00536	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00536	Suspected for Damping Off (Fusarium sp./spp.)
15-00536	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00537	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00537	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00537	Suspected for Damping Off (Fusarium sp./spp.)
15-00537	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00538	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00538	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00538	Suspected for Damping Off (Fusarium sp./spp.)
15-00538	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00539	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00539	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00539	Suspected for Damping Off (Fusarium sp./spp.)
15-00539	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00540	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00540	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00540	Suspected for Damping Off (Fusarium sp./spp.)
15-00540	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00541	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00541	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00541	Suspected for Damping Off (Fusarium sp./spp.)
15-00541	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00542	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00542	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00542	Suspected for Damping Off (Fusarium sp./spp.)
15-00542	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00543	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00543	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00543	Suspected for Damping Off (Fusarium sp./spp.)
15-00543	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00544	Suspected for Pythium Damping Off (Pythium sp./spp.)
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15-00544	Suspected for Damping Off (Fusarium sp./spp.)
15-00544	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00545	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00545	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00545	Suspected for Damping Off (Fusarium sp./spp.)

Sample #	List of Diagnosis/ID(s)
15-00561	Suspected for Pythium Damping Off (P
15-00561	Suspected for Damping Off (Fusarium ;
15-00561	Suspected for Unspecified Pathology (C
15-00561	Suspected for Rhizoctonia Damping Of
15-00562	Suspected for Pythium Damping Off (P
15-00562	Suspected for Damping Off (Fusarium ;
15-00562	Suspected for Unspecified Pathology (C
15-00562	Suspected for Rhizoctonia Damping Of
15-00563	Suspected for Pythium Damping Off (P
15-00563	Suspected for Damping Off (Fusarium ;
15-00563	Suspected for Unspecified Pathology (C
15-00563	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00564	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00564	Suspected for Damping Off (Fusarium sp./spp.)
15-00564	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00564	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00565	Suspected for Pythium Damping Off (Pythium sp./spp.)
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15-00566	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00567	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00567	Suspected for Damping Off (Fusarium sp./spp.)
15-00567	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00567	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00568	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00568	Suspected for Damping Off (Fusarium sp./spp.)
15-00568	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00568	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00569	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00569	Suspected for Damping Off (Fusarium sp./spp.)
15-00569	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00569	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00570	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00570	Suspected for Damping Off (Fusarium sp./spp.)

15-00581	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00582	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00582	Suspected for Damping Off (Fusarium sp./spp.)
15-00582	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00582	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00583	Suspected for Pythium Damping Off (Pythium sp./spp.)
15-00583	Suspected for Damping Off (Fusarium sp./spp.)
15-00583	Suspected for Unspecified Pathology (Colletotrichum sp./spp.)
15-00583	Suspected for Rhizoctonia Damping Off (Rhizoctonia sp./spp.)
15-00584	Suspected for Pythiu
15-00584	Suspected for Dampi
15-00584	Suspected for Unspe
15-00584	Suspected for Rhizo









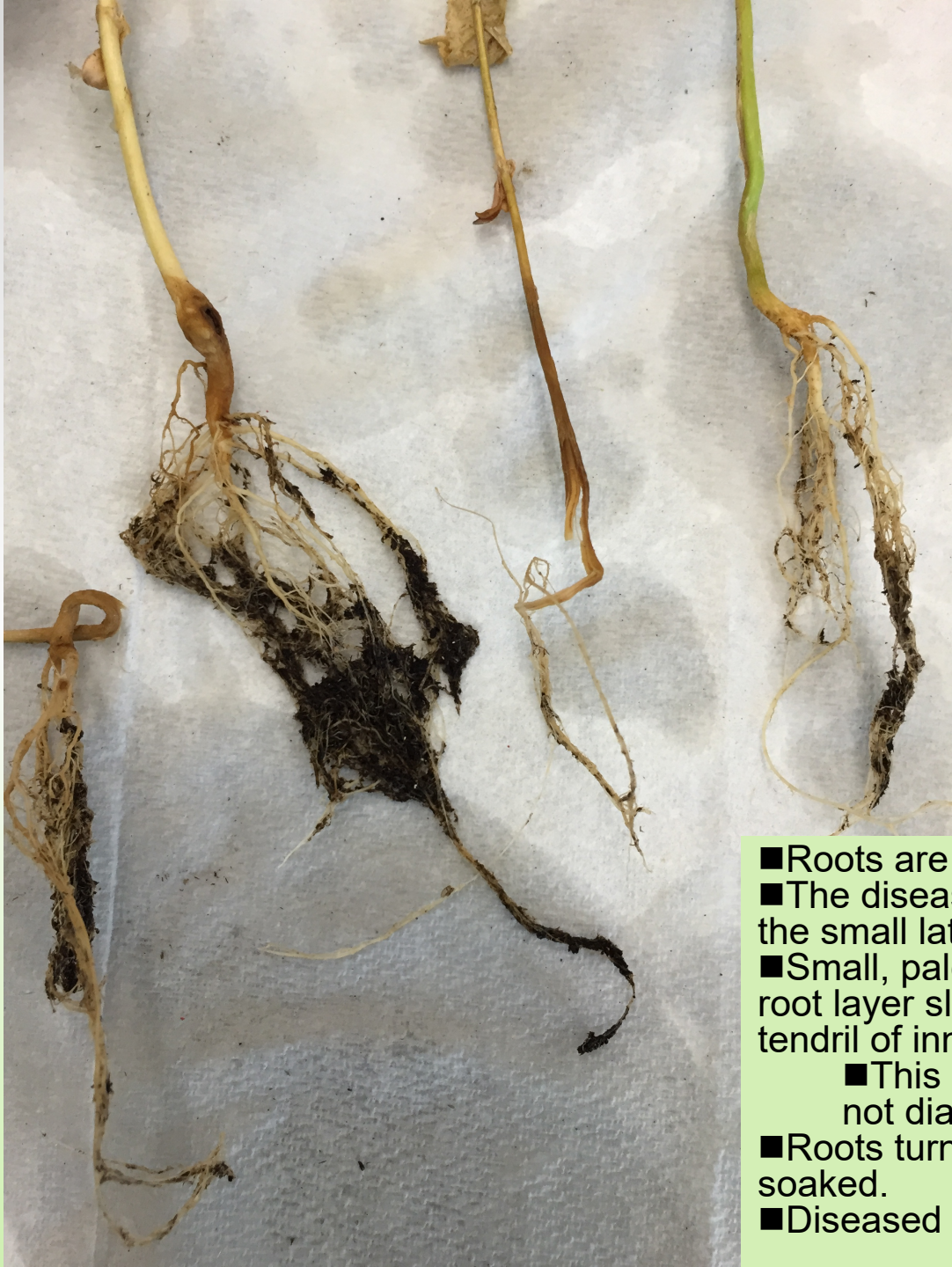
The Most Excellent Undergraduate Tag-Team of Hannah Nisonson and Jess Stone



# Pythium







- Roots are discolored
- The disease often starts as a discoloration of the small lateral roots and root tips.
- Small, pale brown lesions girdle the root, outer root layer sloughs off, leaving behind a thin tendrill of inner root (steele).
  - This rat-tail appearance is common (but not diagnostic!) for PRR
- Roots turn dull brown to black and water-soaked.
- Diseased roots tend to break easily



# Pythium Management

- Greenhouse:
- Avoid overfertilization
- Avoid overwatering
- Ruthlessly exclude symptomatic or highly susceptible plants from ebb-flow.
- Use plants with similar moisture requirements in mixed containers
  - Control fungus gnats and shore flies in containers by using the right soilless mix
- In an agronomic setting:
  - Tiling
  - Plant on fields that have good drainage
  - Avoid areas that were previously planted in beans or sunflower



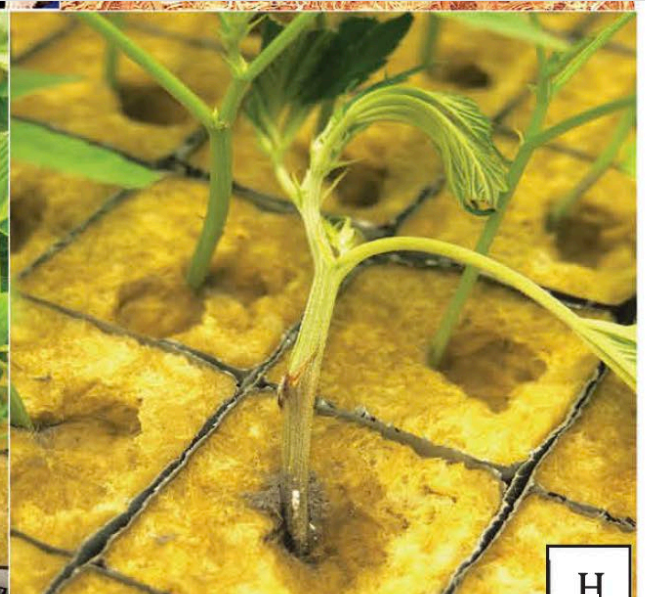




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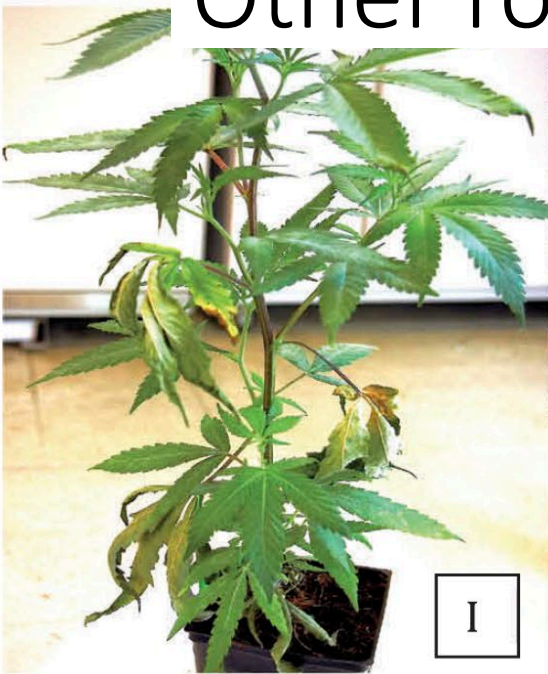


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H

Other root rots: *Fusarium* spp.



I

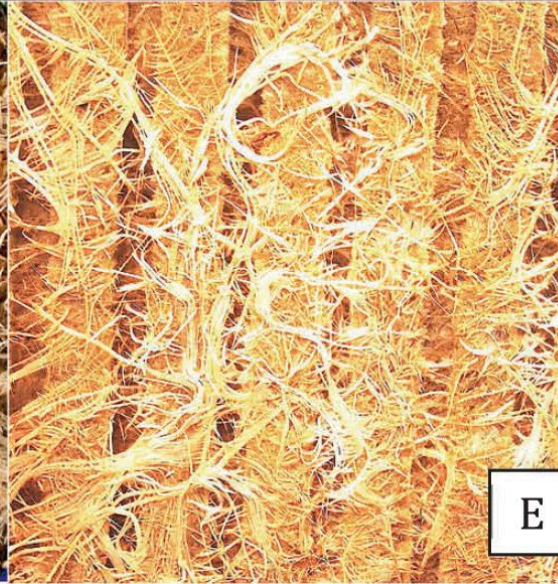
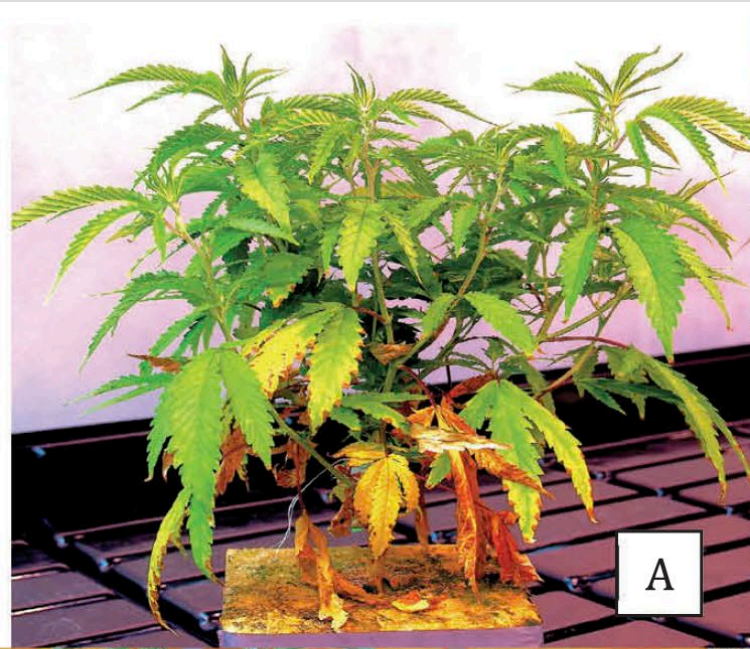


J



K





Other root rots: *Fusarium spp.*

Punja and Rodrigues 2019



# Crown Rots: *Sclerotinia sclerotiorum*

Also causes a stalk rot



From <http://www.hemptrade.ca/eguide/production/diseases>



# Sclerotinia management

- Avoid planting close to or in rotation with soybean, sunflower, legumes or rye.
- sclerotia numbers begin to decline if left undisturbed.
  - viability is maintained if sclerotia are buried 8 to 10 inches in the soil.
  - Greater tillage also promotes earlier canopy development, thus increasing the risk of white mold.
- Weed control is critical as many broadleaf weeds are hosts of the white mold pathogen.



# Crown Rot: *Sclerotium rolfsii*



Photo: Clint Walker, grower, photo courtesy of Alan Windham, University of Tennessee



# Southern blight management

- Increase air circulation with proper plant spacing.
- Sanitation:
  - Remove infected plants and soil surrounding the plant.
- Weed control
- Prevent spread through thorough sanitation
  - Clean boots, shovels, after contact with contaminated soil.
  - Do not replant with susceptible species...which is a lot of species.

# Hemp is susceptible to several foliar diseases, including:



- Powdery Mildews
- Rust
- Downy Mildew
- Leaf Spots
  - Cercospora leaf spot results in circular, depressed sunken centers.
  - Phoma leaf spot has been reported to reduce yield.
  - Colletotrichum spp.
  - Dreschlera spp., Exserohilum spp. and Bipolaris spp.
  - Septoria spp.
- McPartland (1995) described these and other pathogens, but did not describe the economic impact of these species.



Diagnosis is essential: PM versus pollen (or Cannabis semen!)



# Powdery Mildew Management

- Use resistant cultivars when available and when identified
- Plant in non-shaded areas.
- Space plants providing enough aeration and growing room.
- Prune and thin out branches
- monitor for signs of infection
- Remove infected leaves
- Provide enough moisture, always watering in the morning or late afternoon.





# Rust

- Use resistant cultivars when available and when identified
  - We have found 'Sweet', 'Cherry' and related varieties to be very susceptible.
- Plant in non-shaded areas.
- Space plants providing enough aeration and growing room.
- Prune and thin out branches to improve airflow
- Monitor for signs of infection
- Remove infected leaves
- Provide enough moisture, always watering in the morning or late afternoon.





# Downy Mildew Photos by Damon Smith





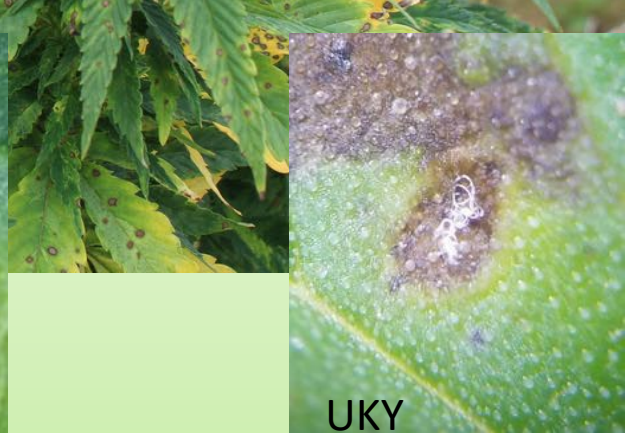
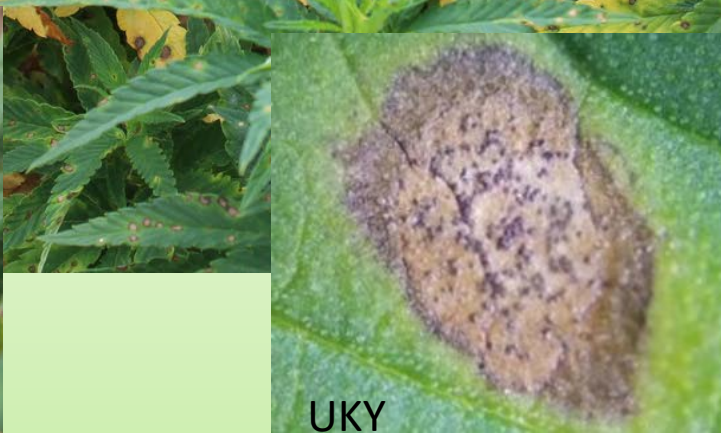
# DM Management

- Start with disease-free material.
- Water early in the day.
  - Easy on the fertilizer!
- Monitor regularly and remove infected plants as they appear.
  - Spores easily spread between plants.
  - Downy mildew overwinters in infected plant debris in the soil and even in weed hosts.
- Temps: 40-60 degrees F are ideal for most DMs.





# Septoria Leaf Spot





# Exerhohilum





# Drechslera gigantea





# Botrytis



UKY

# Botrytis Management

- In greenhouse, monitor humidity and keep below 85%
- To promote rapid drying of plants, space them to allow good air circulation.
- Increase supplemental lighting during cloudy periods.
- Likewise avoid overhead watering, or misting plants especially if Botrytis blight has been troublesome in the past.
  - Do not scout when plants are wet with dew or rain since this could spread fungal spores during conditions which favor infection.
- While inspecting plants carry a paper bag for sanitation.
  - Remove faded or blighted leaves or entire plant if infected at the base
    - Remember that this fungus can overwinter as tiny, black sclerotia embedded in dead plant tissue.



# Bacterial Leaf Spot

- 200 plant pathogenic bacteria
- Difficult to manage
- Prevention is key to effective management
- Symptoms are usually angular leaf spots
- Spreads through surface water and injuries





- Hemp foliar diseases usually begin at the base of the plant and work their way up.
- Improved plant spacing is needed to manage these diseases



# Unknowns.





Hemp has chimeras and abiotic issues...didn't go into...but growers need to be aware of the problems





# Hemp has viruses





# No EPA approval for Hemp Pesticides

- The use of pesticides not registered on Cannabis is illegal.
- Pesticide registration works top down, from Federal to State
  - EPA, OPP, FDA, USDA
  - All cannabis is Schedule 1.
- Cannabis cultivation has to be clarified for different production schemes.
  - Industrial hemp—fiber and seed may be different
    - Worker exposure
    - consumption of oil for oil producing crops
    - Fiber-contact
  - Consumption
    - to obtain data to evaluate the potential toxicity of acute, short-term, intermediate, and chronic exposure after consumption
  - Inhalation
    - to determine the breakdown products formed when the treated plant material is burned
- On biological control: "investigators often attempt unsuccessfully to compensate for anticipated poor performance in antagonist–disease combinations by making more applications."







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