

A large background image showing a dense field of bright green hop cones, which are the seed cones of the hop plant used in brewing.

Roles of Soil Health, Cover Crops & Nematodes in Hop & Barley Production

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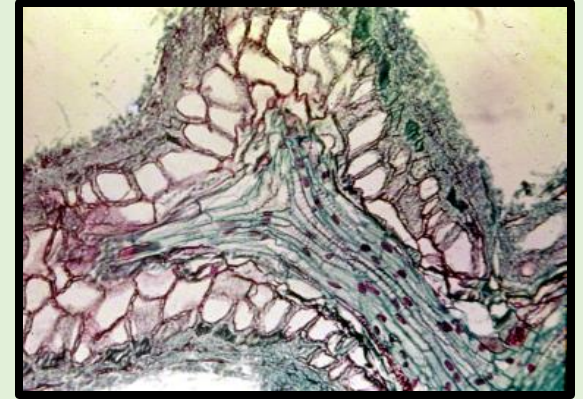
SOIL HEALTH



- A relatively new domain of science (Hot Topic).
- The Michigan experience.
 - 2012 survey results
- Cornell University Soil Health Laboratory
 - 12 soil health indicators
- My favorites
 - Water stable aggregates
 - Nitrogen mineralization potential
 - Active carbon
 - Thermo-stability



Soil-Borne Organisms



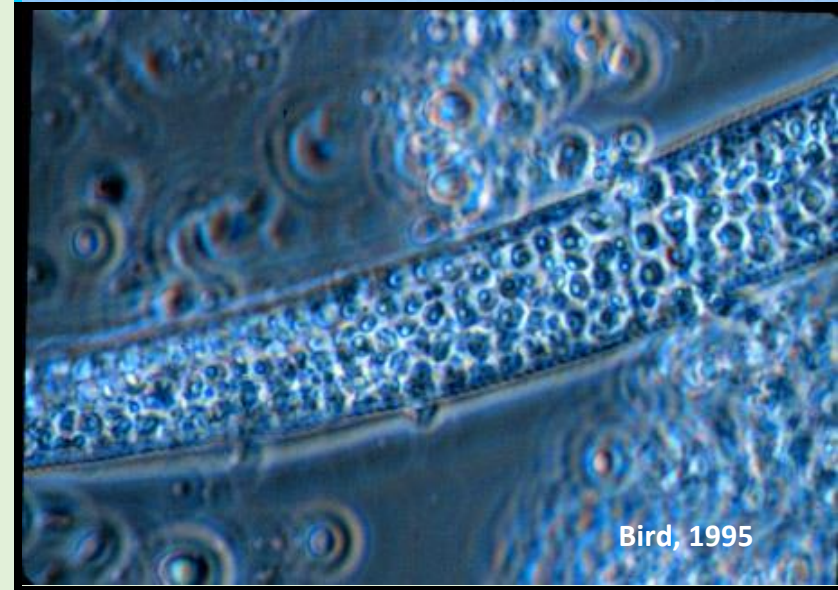
- To understand soil health, you must know your soil-borne friends and what they do for you.
- Who are they?
 - **Bacteria**
 - **Nematodes**
 - **Ciliates**
 - **Fungi**
 - **Amoebae**
 - **Arthropods**
 - **Actinomycetes**
 - **Flagellates**
 - **Earthworms**

Transport and Transformation of Energy and Matter Example

- Bacterial parasitism of a fungal feeding nematode.
- Former *nematode* cuticle full of *bacterial* endospores.

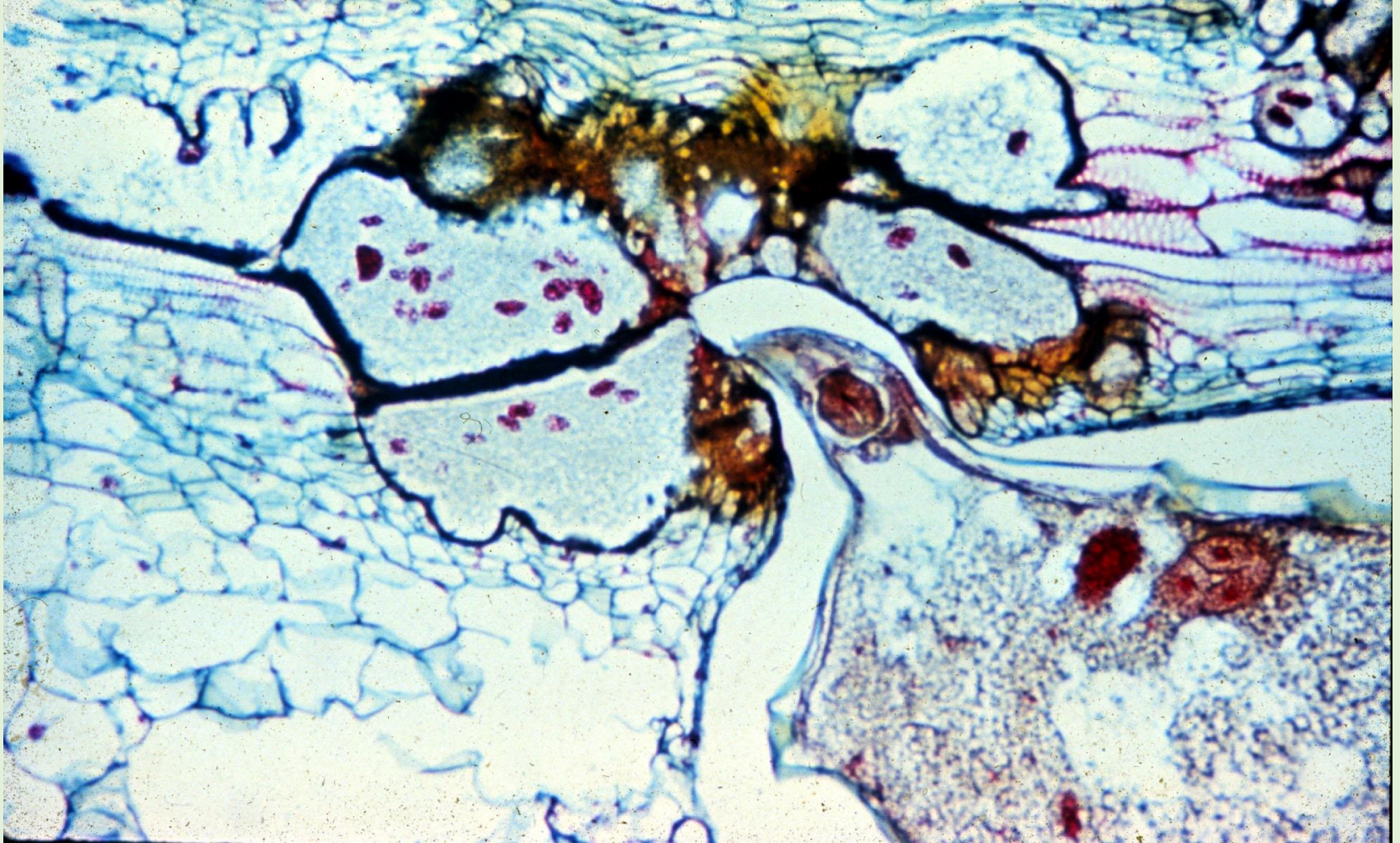


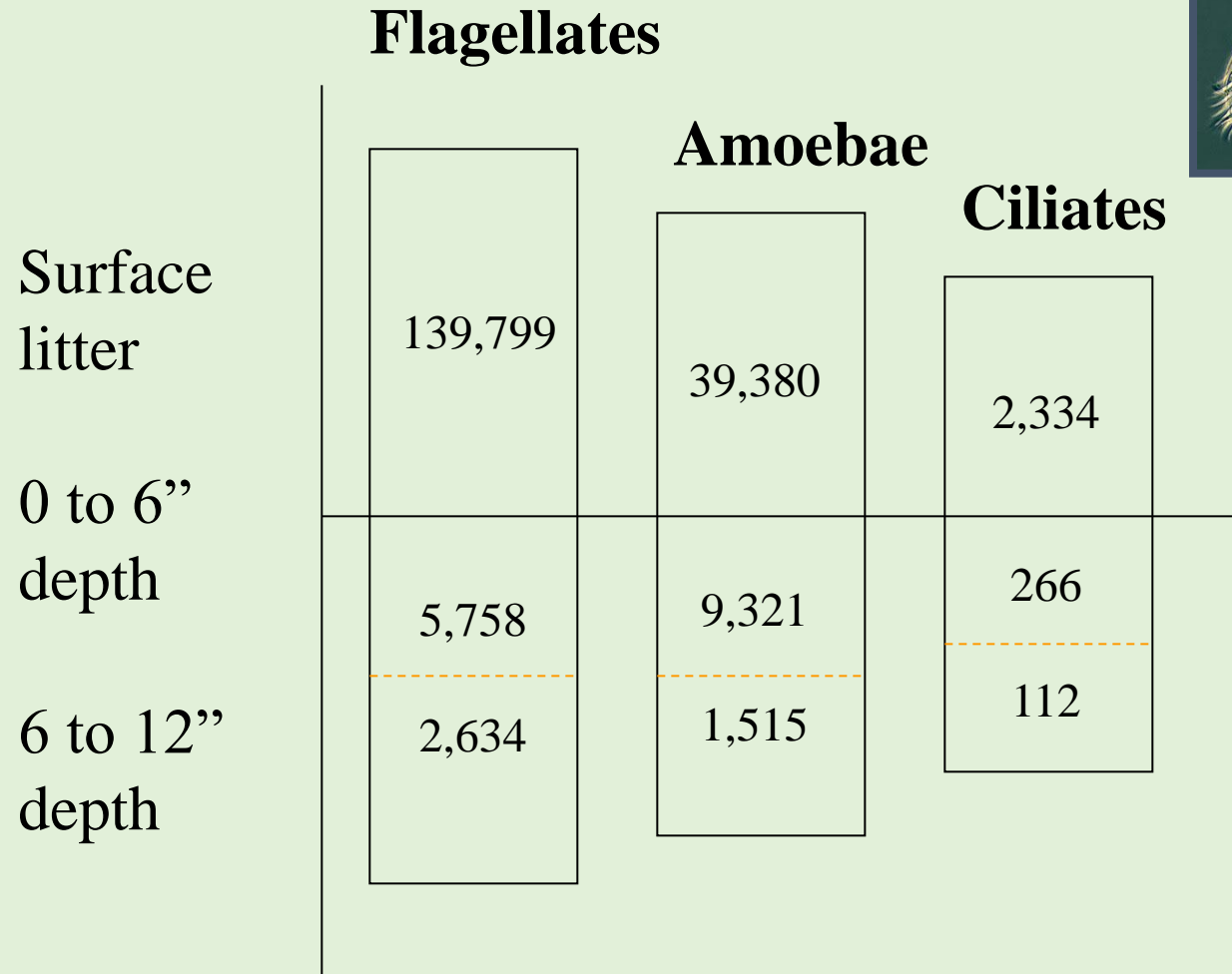
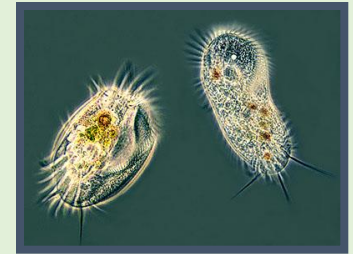
Bird, 1995



Bird, 1995

Do organisms talk to each other?





Where do they live?

(Bird and Smith, 2013).

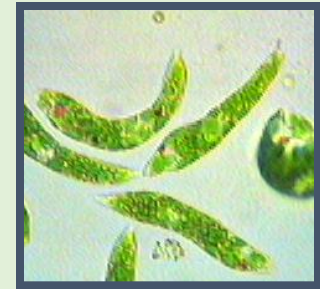
Proof of where they live
and do their thing.



Farming systems vary

Flagellates

	Organic	Conventional
Surface litter	258,344	21,235
0 to 6" depth	6,991	4,524
6 to 12" depth	2,342	2,928



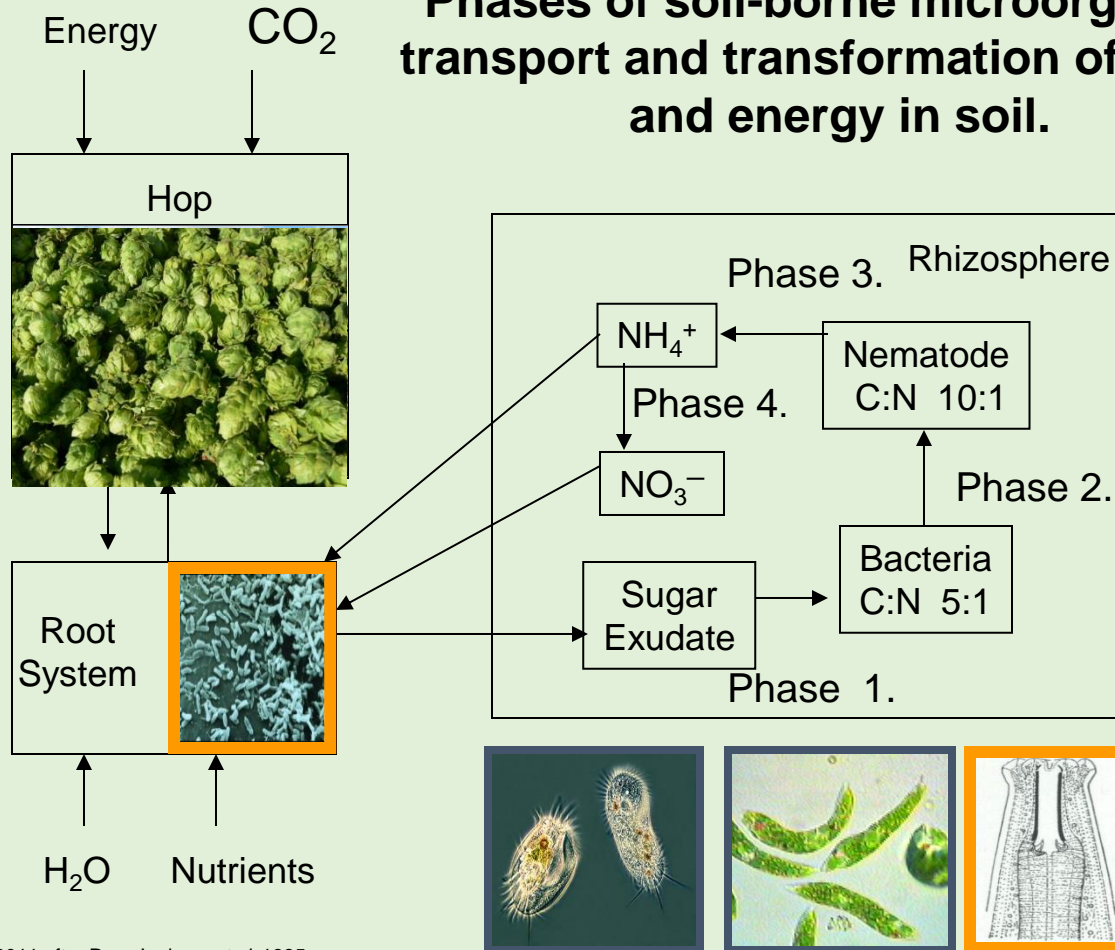
Now back to my
favorite indicators

Water Stable Aggregates



Nitrogen Mineralization

Phases of soil-borne microorganism transport and transformation of matter and energy in soil.



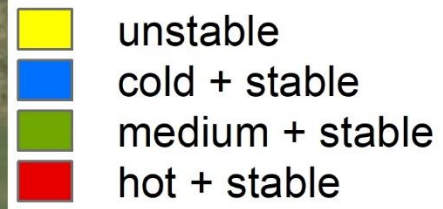
Bird, 2011 after Russ Ingham *et al*, 1985.

Active Carbon



42

Thermal Stability Map
level: 5°C; t_var: 0.5°C
2017



Hot and variable

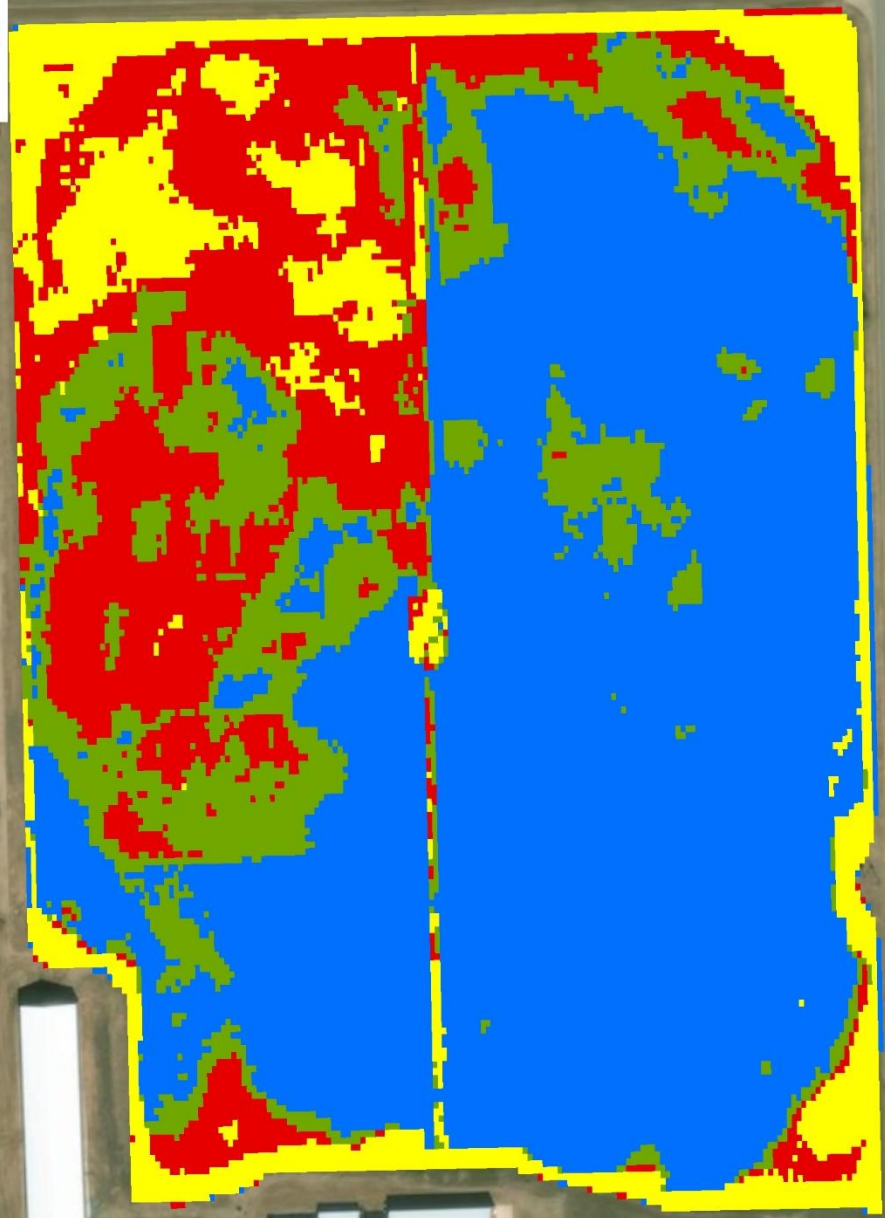
300 cwt/A

66% WSA

4.5 N Index Value

213 ppm Active C

2,569 *D. obscurus*



Cold and stable

462 cwt/acre

69% WSA

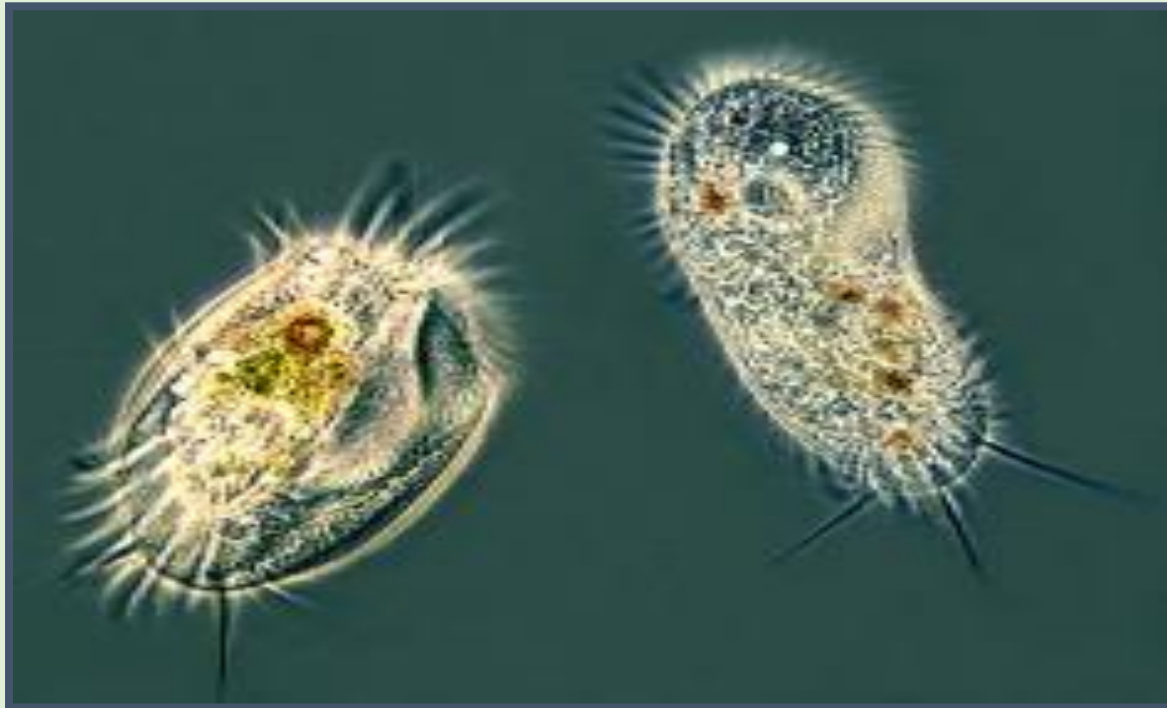
5.0 N Index Value

314 ppm Active C

163 *D. obscurus*

Let's Watch Them Work

Life in the Soil Video



Cover Crops



Cover Crop Functions (n = 14)

- **Soil Builders**
- **Soil Compaction Reducers**
- **Soil Water Conservers**
- **Erosion Fighters**
- **Nutrient Sources**
 - **Nitrogen**
 - **20 essential elements**
- **Hay Crops**
- **Silage Crops**
- **Seed Crops**
- **Livestock Grazers**
- **Pest Managers**

Functions of Cover Crops as Pest Managers

- **Weed Fighters**
- **Pest Starvers (Non-Hosts)**
- **Pest Trappers (Two Types)**
- **Toxicant Producers**
 - **Soil Fumigators**
- **Matter and Energy Resources for Biological Control Agents (Food for Your Friends)**

Three Laws for Successful Cover Crop Use

- Identify the specific objective(s) for the each cover crop planting.
- Select the proper cover crop **variety** for the objective (not the cover crop type, but a specific cultivar). The variety of the cover crop is as important as the variety of the associated cash crop(s).
- Design and implement the optimal cover crop management practices for achieving the desired objectives.

Cover Crop Types and Blends

- Gramininaceae
 - Grains (Cereal rye cv Wheeler) etc.
- Legumes
 - Alfalfa, Red Clover, White Clover etc.
- Brassicas
 - Mustards and Radish
- Buckwheat
- Cover Crop Blends



Critical Question: Are plant-parasitic nematodes pathogens of importance on hop and barley?

YES



Penetrans Root-Lesion Nematode

Most common plant parasitic nematode in Michigan (*Pratylenchus penetrans*).

It can significantly reduce barley grain yields.

Situation unknown for hop.

Does it interact with In hop, the *Verticillium nonalfalfae* (formally *V. albo-atrum*) on hop?.

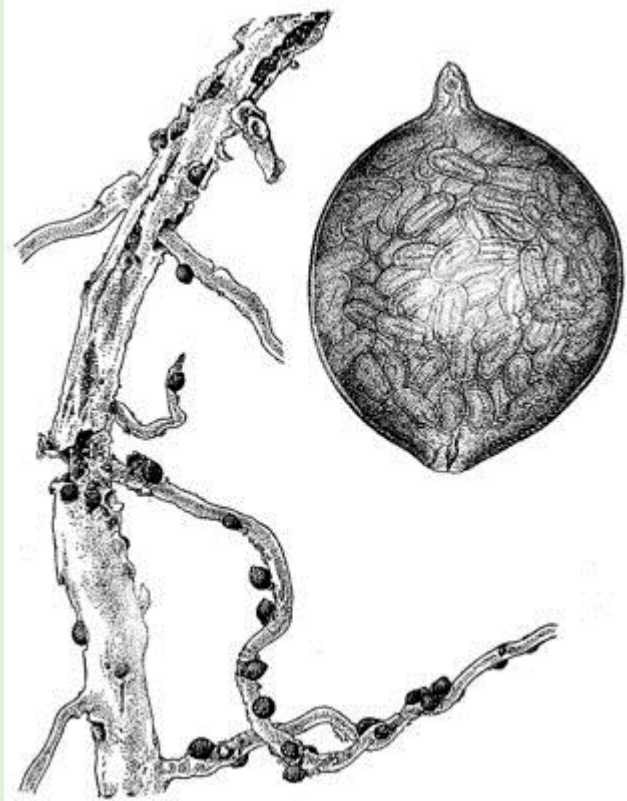


Root-Knot Nematodes Hop and Barley

On a world wide basis, root-knot nematodes, *Meloidogyne* spp., are responsible for the greatest amount of yield loss caused by plant-parasitic nematodes. In Michigan we only have one species (northern root-knot nematode). Barley is not a host for this nematode. Root-knot nematode impacts on hop are not well documented.



The hop cyst nematode, *Heterodera humuli*



Angela Tenney

Cyst nematode white females on root tissue.

The Hop Cyst Nematode (*Heterodera humuli*) can reduce hop yield decrease of 50% and also reduce quality. Yield loss depends on the nematode population density .

Hop Cyst Nematode

(Heterodera humuli)

- Michigan
 - First detection in 2012 from Traverse City area.
 - Sample contained 241 *H. humuli* cysts/100 cc soil.
- On a global basis, Hop Cyst Nematode is regarded as the most important plant parasitic nematode associated with hop.

Dagger Nematode
(*Xiphinema* spp.)

Virus Vector



Arabis Mosaic Virus

Arabis mosaic virus (ArMV) is also called raspberry yellow dwarf virus and rhubarb mosaic virus.

ArMV has multiple hosts, including strawberries, hop, hemp, grape and geraniums, raspberries, sugarbeets, celery, horseradish, lilac, peach and lettuce.

ArMV is a nepovirus with the primary vector being the dagger nematode, *Xiphinema diversicaudatum*.



Hop with nettlehead symptom caused by ArMV.

Photo by A. Eppler

Distribution of ArMV

EPPO region:

Belgium, Bulgaria, Cyprus (found but not established), Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Moldova, Netherlands, Norway, Poland, Romania, Russia (European, Far East), Slovakia, Sweden, Switzerland, Turkey, UK, Ukraine and Yugoslavia.

Asia:

Japan, Kazakhstan, Russia (Far East), Turkey.

Africa:

South Africa.

North America:

Canada (Michigan, British Columbia, Nova Scotia, Ontario and Quebec).

Oceania:

Australia (Tasmania, Victoria), New Zealand.

ArMV in Michigan

MDARD commonly detects ArMV on.

A MSU survey of 240 MI vineyards detected ArMV in 0.2% of the sited surveyed.

As of September 2018, ArMV has not been detected on hops grown in MI.



Other Ectoparasitic Nematodes of Barley

Needle

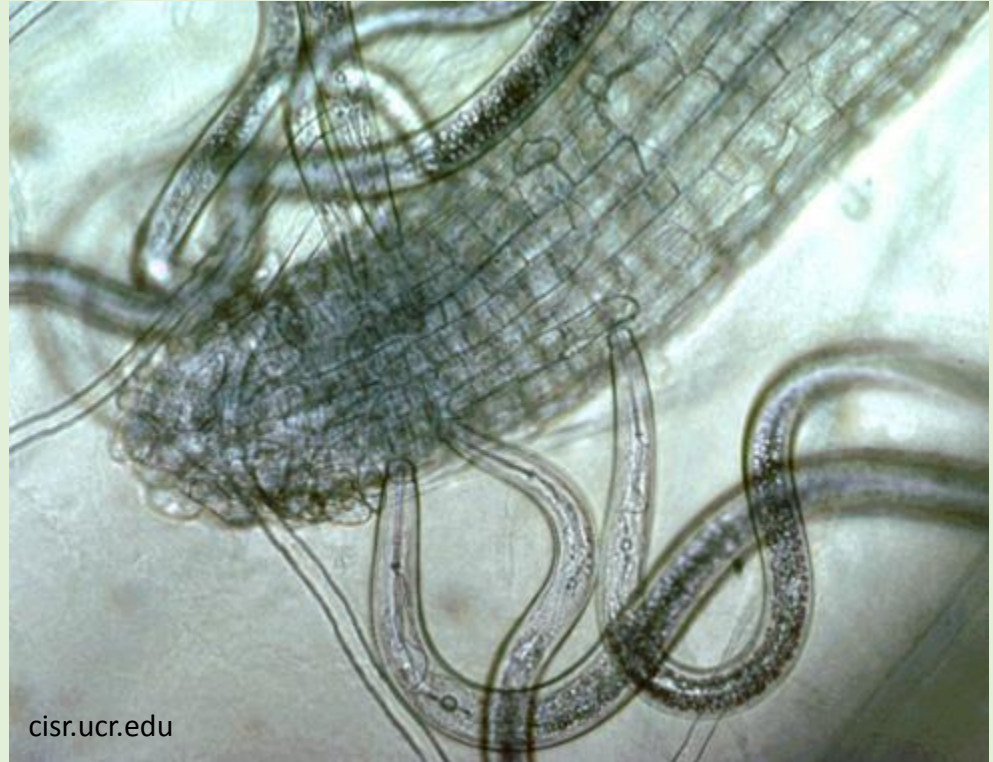
Stubby-root

Pin

Spiral

Stunt

**Nothing known about
these nematodes in
relation to hop
production in Michigan**





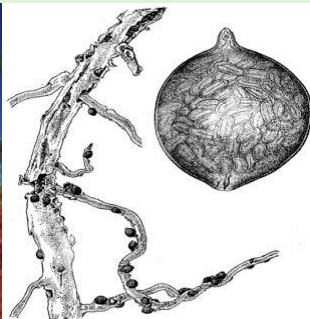
Conclusions

1. Soil Health: A hot and emerging topic.
2. Cover Crops: Remember the three Laws and do not believe everything you read on the label.
3. Nematodes: Good nematode data base for grain crops.
4. With the exception of the hop cyst nematode, *Heterodera humuli*, the impacts of nematodes in hop are largely not documented.
5. Post-plant control options are limited although Mocap is labeled for use on hop. Regardless, cyst nematodes are typically difficult to control chemically.

Soil Health References

- Lehman *et al.* 2015. *Understanding and Enhancing Soil Biological Health; Sustainability* 7:988-1027.
- Basso, B. *et al.*, 2011. *Procedures for Initializing Soil Organic Carbon Pools in the DSSAT-Century Model for Agricultural Systems.* *J. Soil Sci. Soc. Amer.* 75:69-78
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- Montgomery, D. 2007. *Dirt: The Erosion of Civilizations.* Univ. Calif. Press, Berkeley.

42
Thermal Stability Map
level: 5°C; t_var: 0.5°C
2017



*A civilization,
Nation or food
system is only as
healthy as the
health of its soil.*

