AzCATI

Arizona Center for Algae Technology and Innovation

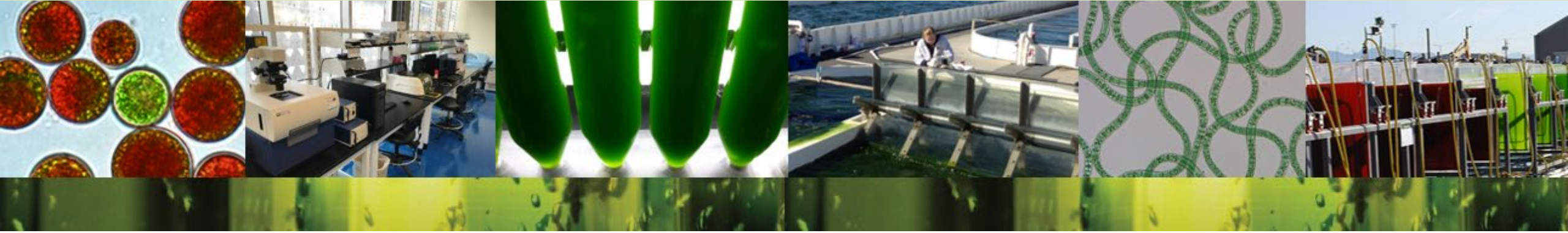
One little cell, a world of possibilities.

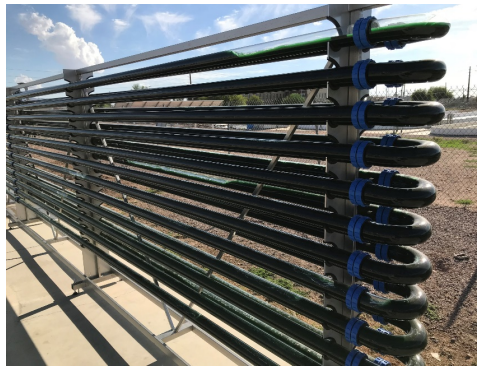
Algae Crop Protection Workshop
Session 1: Current State of Crop Protection

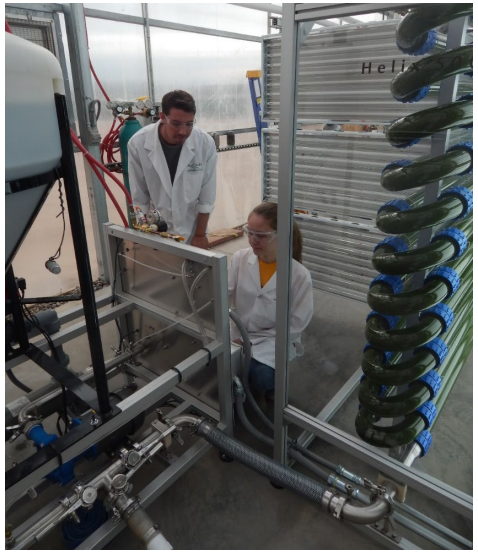
Perspectives from an academic algae testbed

Dr. John McGowen
Director of Operations and Program Management

ASU Ira A. Fulton Schools of Engineering
Arizona State University







www.azcati.asu.edu

Who we are:

The Arizona Center for Algae Technology and Innovation (AZCATI) is located at Arizona State University's Polytechnic Campus and is part of the Fulton Schools of Engineering.

The Center's Mission:

AzCATI serves as a national algae testbed to accelerate the advancement of algae technology development and commercialization through innovative **research**, **education**, and **collaboration**.

ASU Ira A. Fulton Schools of Engineering
Arizona State University

SCIENCE foundation ARIZONA
Innovation at Work

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AzCATI: Connect and Collaborate

AzCATI has an extensive network of collaborators both within and outside of ASU with partners offering access to wide range of expertise, research capacity and high-quality services.

Core research areas at ASU/AzCATI include

- Bioprospecting, algal taxonomy and physiology
- DNA-based strain-typing services
- Algal consortia
- Carbon capture and utilization
- Carbon dioxide air capture and membrane delivery
- Water and wastewater treatment
- Acidophilic red algae for multi trophic production of biomass and valuable co-products
- Development of heat tolerant systems for cultivation in hot-arid environments
- Novel sensor development for water and soil quality, and process monitoring
- Biomass extraction and conversion to biobased products with focus on circular/regenerative pathways/technologies
- Process integration and system scale-up
- Long term cultivation studies and crop protection
- Technoeconomic analysis and life cycle assessment

Serving the algae industry

Strain Identification & Isolation

Isolate specific strains and provide unialgal, or axenic cultures for clients that have issues with mixed or contaminated cultures.

Biomass Production & Supply

Supply biomass production and culture maintenance services to industry and academic customers from laboratory to pre-commercial scale, including genetically engineered strains. Extensive experience conducting outdoor cultivation trials and GMO-TERA application support.

Analytical Services

Provide analytical services to measure microalgae growth, biochemical composition and water (culture media) quality characteristics.

Equipment Testing

Our testbed is equipped with existing infrastructure for plug-n-play testing of algae cultivation systems, harvesting and dewatering pilot equipment, and other algae innovations.

Education & Training

We offer courses ranging from basic algae taxonomy and physiology to in-depth, hands-on training using advanced analytical techniques and data analytics for improved operations.

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Sharing High Impact Data

Central to AzCATI's mission is the sharing of data (and SAMPLES) from our Department of Energy (DOE) funded long-term cultivation trials, setting the standard for the acquisition of high-quality productivity data and proximate analysis to help inform the assessment of the current state-of-technology for algal based biotechnology.

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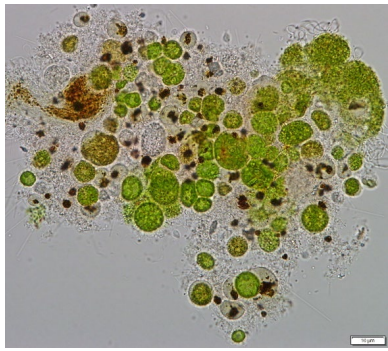
If you are cultivating algae, you are cultivating pests

- **Outdoor cultivation on site since 2009**
  - Majority PBR cultivation 2009-2012
  - Majority open pond cultivation 2012-2021
  - *Nannochloropsis* sp.*, Chlorella* sp.*, and Scenedesmus* sp. through 2015 (nitrate-based media)
  - Strain diversity increased 2015-2021 *(Desmodesmus* sp., *Monoraphidium* sp.*, Picochlorum* sp., *Nannochloris* sp. *Tetraselmis* sp., *A. platensis, Micractinium* sp., *Scenedesmus* sp. *Chlorella* sp. and *Nannochloropsis* sp.)
  - Diversity of media types
    - Freshwater to brackish to marine
    - Mainly ammonia-based media since 2015
  - And since 2018 we have had two (2) or more strains in cultivation every single day of the year – lots of opportunities for pest observations and improving strategies to manage
- **Pests are always present and not always detrimental**
- **Unless or until they are…**



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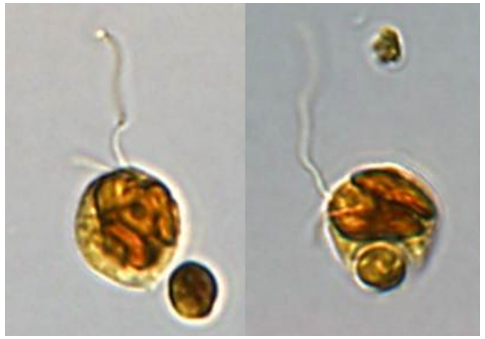
What pests are we cultivating?

Depends on what algae we are growing

- Each strain has its own pests
- For most of the early cultivation years at AzCATI, grazers dominated as the pests of most concern
  - *Chlorella*: mainly golden algae (*Poterioochromonas* sp.) and other grazers (rotifers, vorticella, ciliates, amoeba)
  - *Nannochloropsis:* amoeba (ciliates, vorticella)
  - *Scenedesmus:* ciliates (vorticella, rotifers, amoeba)
  - Some grazers are rarely observed anymore and in particular for rotifers – their decline in activity likely linked to a shift to predominantly ammonia-based media since 2015
  - But others remain very active (amoeba, vorticella)
- More recently other pests have emerged as the dominant threat including fungal parasitoids and predatory bacteria



Poterioochromonas sp. ingesting *Chlorella* (fixed/stained)

Rotifer with *Chlorella*

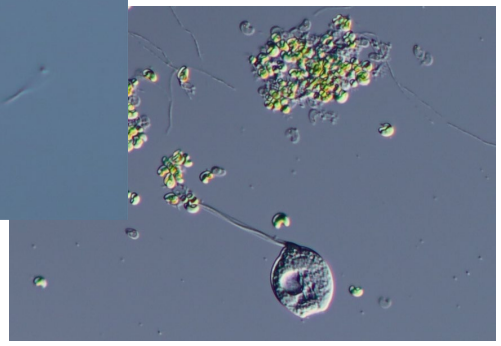
Vorticella sp. and amoeba in *N. granulata*

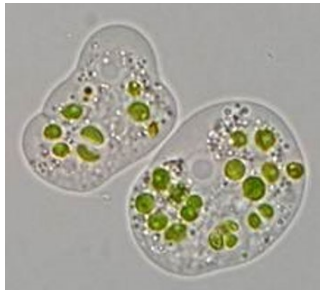
Euplotes sp. in *N. granulata culture*

Amoeba in *Micractinium* sp.

Amoeba in *A. obliquus*

Vorticella sp. in *M. minutum*





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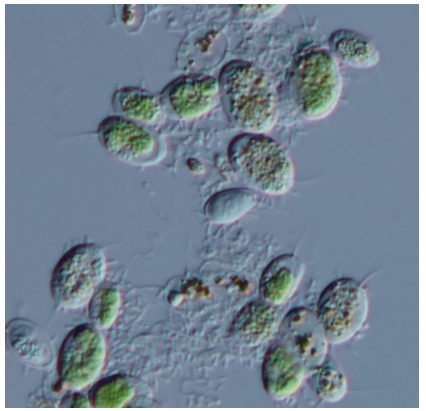
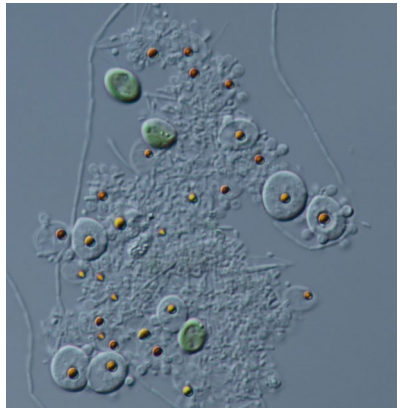
Current Biggest Pest Threats at AzCATI

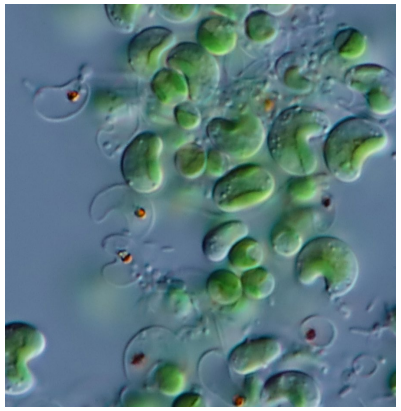
- **Since 2015, we've seen an increase in fungal parasitoids infecting multiple strains**
- **Freshwater to brackish to full marine**
- **Can decimate a culture in days**
- **Host specific and in many cases are obligate parasites (requiring co-culture for pest models)**
- **Some fungal parasitoids identified and PCR for routine monitoring and pest models established – a continuous cycle**
  - New/unidentified parasitoids appear, identified ones disappear and cycle starts anew for pest isolation/ ID/establishing pest model/mitigation/control
  - Lifecycle understood, interrupting it? Not so much…
- **No effective control strategies up until 2019 (but still limited)**
  - pH swings (marginally effective)
  - Dilution rate (even less effective)
  - Salinity/media composition (needs more work)
  - Fungicide can be very effective but strain dependent
  - Seasonally dependent – most active when warm but present and active all year
  - Lots remains to be explored for effective mitigation of fungal parasitoids…



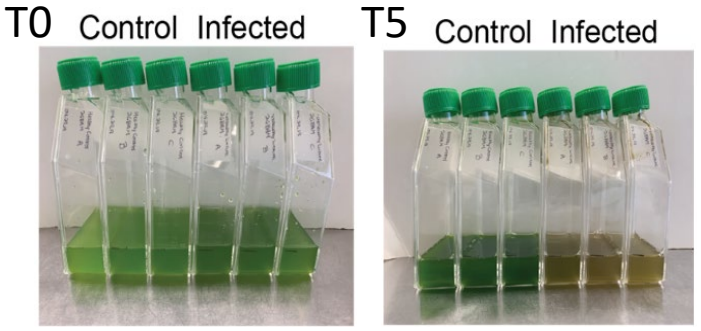
D. armatus infected with unkn. parasitoid

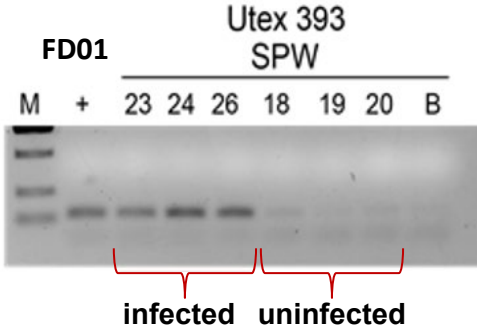


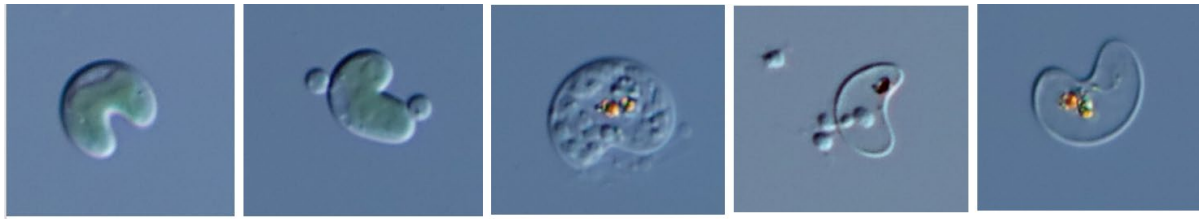
A. obliquus infected with aphelid (FD95)



M. minutum infected with aphelid (FD01)

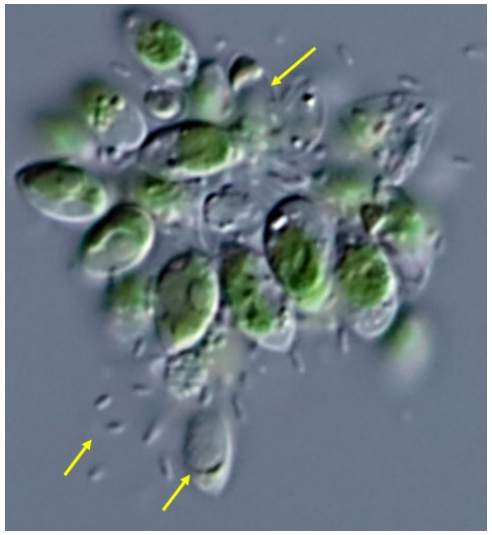


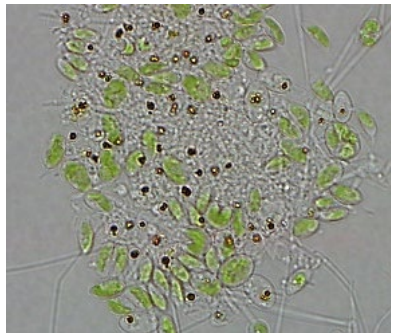


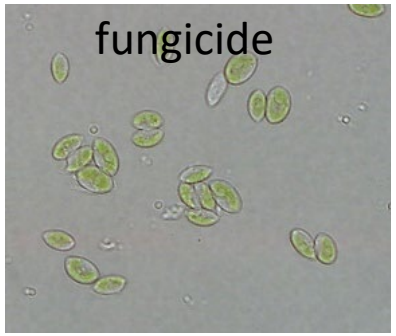


Solve one pest problem? Just wait for the next…

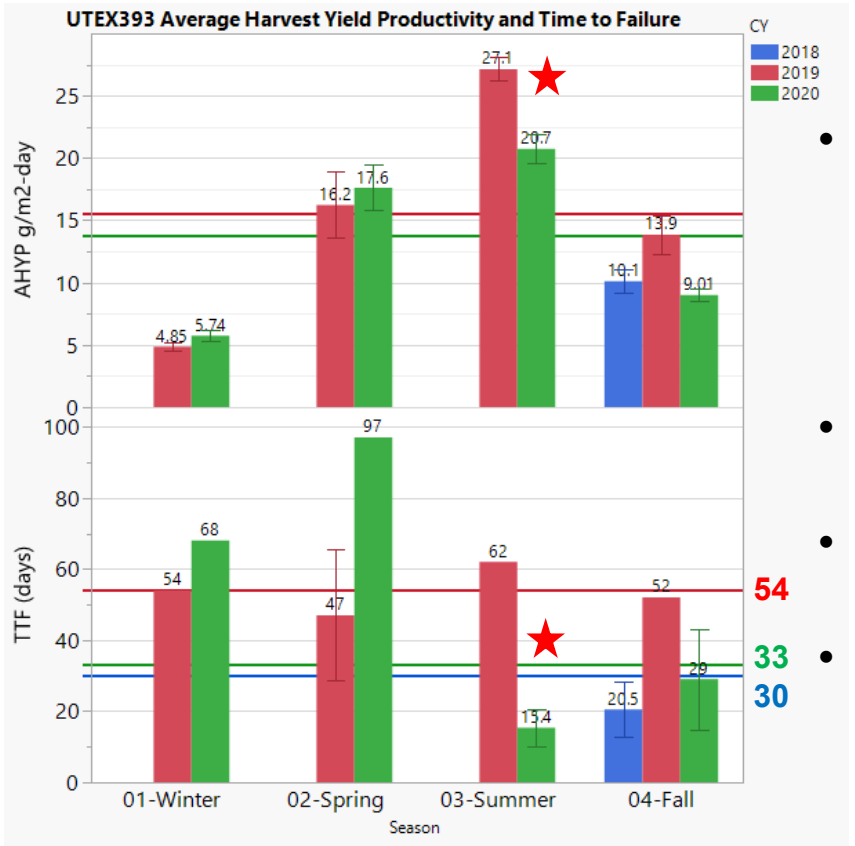
- **UTEX393 cultivated at AzCATI continuously since Fall 2018**
- Rapid culture crashes through Spring 2019
- Looked like a fungal parasitoid - attempted fungicide mitigation in spring 2019
- Increased productivity/reduced culture failure rates
- Increased time to failure (TTF) from 2018 SOT baseline of 30 days to 54 days with cultivation runs in excess ~100 days through Spring 2020
- However, a new contaminant observed in Spring 2020 which looked like a predatory bacterium
- Dropped TTF from over 60 days to ~15 days and lowered productivity



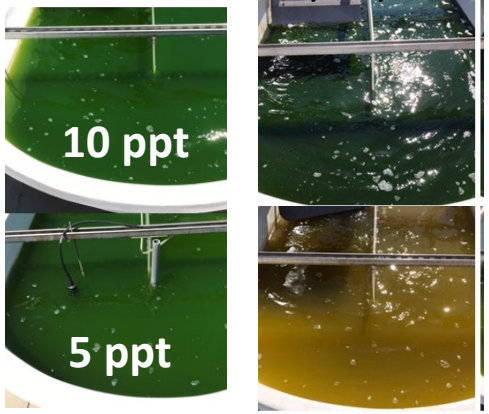




Pre-treatment Post-treatment



8/10/20 8/15/20



- Mitigation with salinity swings increased TTF from ~ 14 days>24 days but cultures still crashed
- Still working to ID this pest
- Pest model established
- Exploring more this spring/summer - currently crashing cultures

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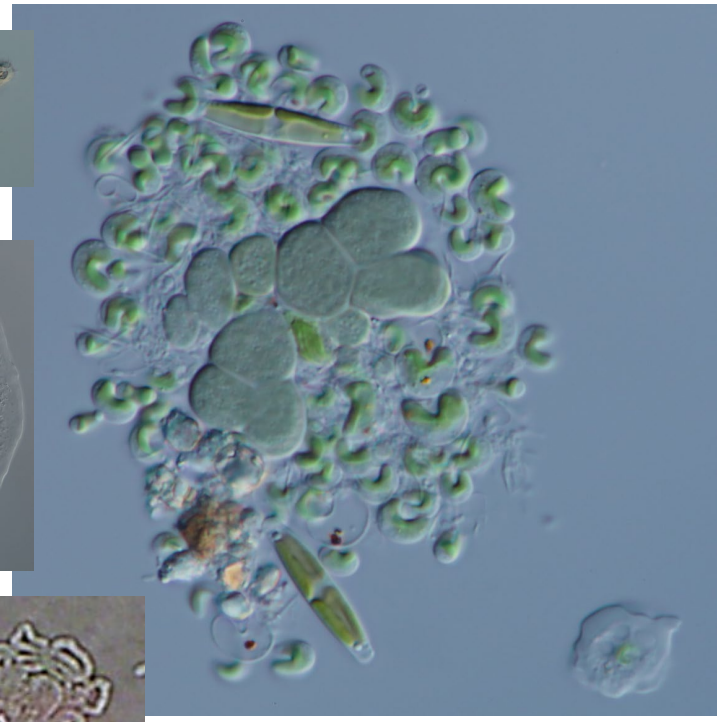
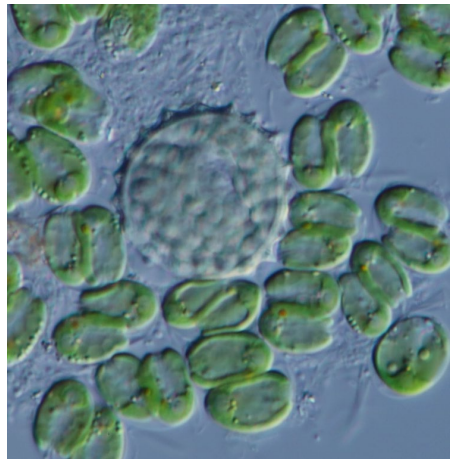
There's always more to do…

- Cultivation of algae outdoors requires active pest management approaches
- Pest pressures change season to season and year over year
- Once a pest shows up – it usually is there for good
- Usually experience a "honeymoon" with new cultivars. But only a matter of time…
- Understanding your crop takes time, patience, and effort – lots and lots of effort
- At least there are always interesting things to look at!





- Special thanks to AzCATI undergrad Aaron Geels for most of the microscopy shown