Solutions to Eastern Filbert Blight

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2nd Annual Ontario Hazelnut Conference
March 23, 2011

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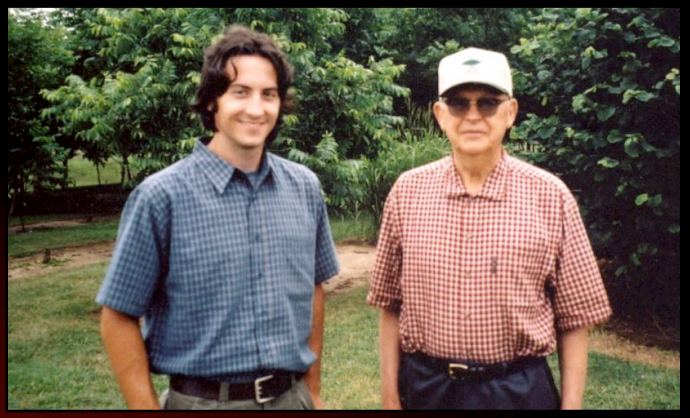
Hazelnut Research at Rutgers

- **Started in 1996 by Dr. Reed Funk as part of a larger project on sustainable perennial nut crops.**
- **The major focus on hazelnuts began in 2000 and has been continued by Dr. Tom Molnar.**
- Searching for sources of resistance to the disease Eastern Filbert Blight.
- Breeding EFB-resistant plants for production in NJ, the Mid-Atlantic region, and other areas.
- Studying the EFB pathogen, *Anisogramma anomala*, and its diversity.



Dr. Tom Molnar and Dr. Reed Funk.

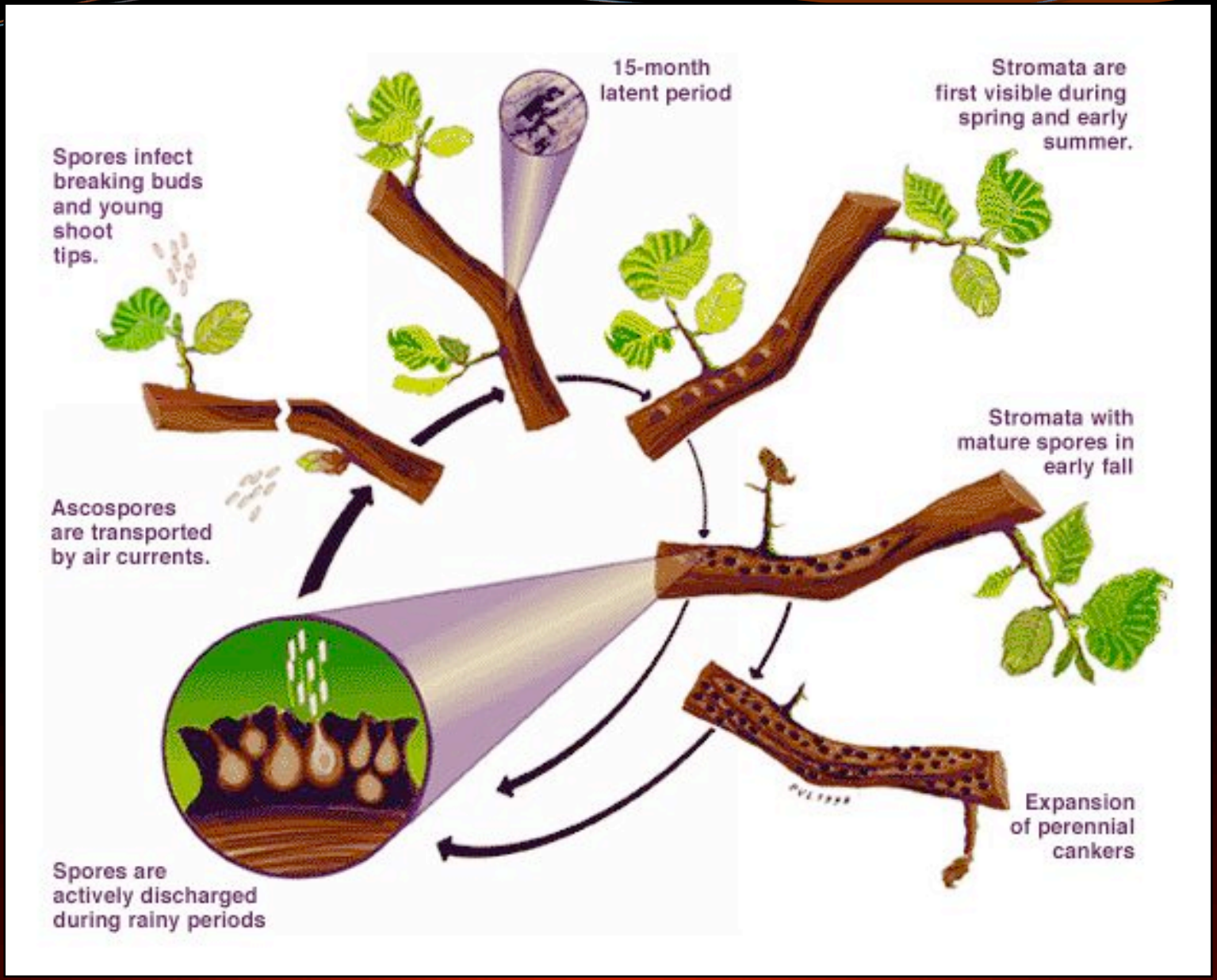
Heavy EFB infection on a contorted plant.

My Role

- **Joined Dr. Molnar's team a little over a year ago to study the *Anisogramma* fungus.**
- **Also assist with some breeding and field work.**
- **Main objectives:**
  - Collect and culture isolates for further study.
  - Understand the genetic diversity among isolates.
  - Note distribution of genetic variability across the native range.
  - Learn more about the fungus to develop improved disease resistance.
  - Find correlations between isolates of EFB and resistance genes that we can pyramid through breeding for more durable resistance.

Eastern Filbert Blight (EFB)

- For amateur and commercial growers alike, EFB is the primary disease adversely affecting hazelnuts in North America.
- It is the main limiting factor in the eastern part of the continent; hazelnut production in that region would otherwise be possible.
- More diversity exists in the east.
- Only appeared west of the Rocky Mountains in the 1960s, which was the start of a serious impact on production in Oregon.
- Disease is endemic to North America, and would have devastating consequences if it should appear in Europe.



Lifecycle of *Anisogramma anomala*. http://oregonstate.edu/dept/botany/epp/EFB/lifecycle.htm

Stages of EFB Development

From: Molnar, TJ, SN Baxer, and JC Goffreda. 2005. Accelerated screening of hazelnut seedlings for resistance to eastern filbert blight. *HortScience* 40:1667-1669

Fungus grows under the bark.

EFB lesion on a branch.

EFB stromata and lesion on stems.

Most of the stems killed by EFB.

Eastern Filbert Blight (EFB)

- European *Corylus avellana* —the hazel species grown for commercial purposes—is generally highly susceptible to EFB.
- The native *Corylus americana* hazelnut is very tolerant, but produce small, thick-shelled nuts.
- Nearby stands of wild hazelnuts can introduce inoculum into plantings.
- If you plant susceptible cultivars, chances are high for eventual infection.
- There are a few different aspects to combatting this disease.

Potential Solutions

- **Unfortunately, like many other diseases, there is no definitive solution for Eastern Filbert Blight.**
- **But a solution means finding an answer—fighting the pest however we can.**
- **Ways we can approach the EFB problem:**
  - Fighting existing EFB with available treatments.
  - Breeding for disease-resistance.
  - Screening for presence of the disease.
  - Understanding the plant-pathogen interaction.
  - Learning more about *A. anomala*.

Existing Treatments

- Chemical control measures are rarely used outside of Oregon, as the Willamette Valley is the only location where significant amounts of hazelnuts are grown commercially in the US.
- Oregon State University provides suggestions for fungicide applications, although various combinations yield similar results. Fungicides can only provide limited control. (http://oregonstate.edu/dept/botany/epp/EFB/)
- Removal of infected plant tissue also reduces inoculum preventing further spread of the disease, and OSU also has suggested pruning techniques online as well.
- However, there are other effective solutions to EFB.

Disease Resistance

- Genetic resistance is the most effective way to prevent EFB.
- We work with OSU and other members of the Hybrid Hazelnut Consortium (University of Nebraska and the National Arbor Day Foundation) to share information and plant breeding material.
- Quantitative (horizontal) and dominant-gene (vertical) resistance.
- At least 9 or 10 novel sources of resistance are known in *C. avellana*, mostly identified in Oregon.
- Other sources are interspecific hybrids, as well as *C. colurna*, *C. heterophylla*, and *C. chinensis,* as well as native *C. americana.*

Disease Resistance

- Breeding for disease resistance includes pyramiding different dominant resistance genes, and we are making crosses with trees developed in Oregon that already contain two genes.
- Various sources of resistance, including trees developed in Oregon are used as parents, to create more durable resistance.
- We are currently evaluating large seedling populations (over 6,000 plants) from Turkey, Poland, Latvia, Lithuania, Moldova, Estonia, and the Republic of Georgia.
- 2-3 unrelated resistance sources have been identified from our collections in Russia and Ukraine.

Some of our new sources of resistance also have improved nut quality, compared to 'Gasaway,' the original known source of EFB resistance.

Disease Resistance

- By continuing to collect germplasm both worldwide and domestically, we increase the diversity of genetic resistance that can be incorporated into breeding objectives.
- Rutgers now has more than 25,000 germplasm accessions and breeding progeny under evaluation in the field and greenhouse, and the collection is rapidly growing.

Disease Resistance

- Developing EFB-resistant plants is the best solution for managing the disease.
- Some resistant plants are already available on the market, though adaptation is uncertain in different regions.
- Choose disease-resistant cultivars for new plantings, including pollinizers.
- Disease-resistance is not always 100% effective—pathogens can evolve, and resistance is not always as effective against all strains of a disease.

Disease Resistance

- Part of our research at Rutgers involves maintaining high disease pressure and exposing trees to various isolates of EFB.
- Although 'Gasaway' has remained resistant to EFB in Oregon for over 30 years, all of the disease in that area likely traces back to a single point of infection.
- 'Gasaway' will become infected in New Jersey (although not heavily), but it's unclear if it is due to a specific race of *A. anomala*.

Several stromata in an infected area on a 'Gasaway' branch.

Disease Screening

- Breeding work requires greenhouse inoculations and screening for EFB to evaluate infection.
- The rapid screening process developed by Molnar et al. (2005) involves germinating nuts in fall with gibberellic acid, inoculating seedlings, and forced overwintering in a cold room; EFB can be expressed in 6-9 months.
- Rutgers recently developed a real-time PCR test to detect EFB months before symptoms.
- Screening both new and established plants—knowing what to look for and recognizing the signs of EFB—will help control disease in your own plantings.

Inoculation chamber.

Seedlings in 100% humidity inside.

Plant-Pathogen Interaction

- **In order to improve breeding methods and to better understand resistance, it is necessary to learn more about how the fungus interacts with the host plant.**
- **Although it is known that the spores infect plants through the tips of growing shoots, we don't fully understand the modes of resistance.**
- **Possible mechanisms of resistance:**
  - Physical barrier prevents spores from entering the plant.
  - Chemical interaction prevents spores from germinating or colonizing.
  - Unknown changes in fungus growth or behavior.

Plant-Pathogen Interaction

- We are currently conducting an experiment to learn how the fungus behaves toward susceptible and resistant plant tissue.
- Susceptible plant tissue has been grafted onto resistant rootstock through chip-budding.
- Trees will be infected during greenhouse inoculation, and we will observe whether the infection is able to cross the graft union into the resistant rootstock tissue.
- More information on the modes of resistance will give more factors to consider in breeding methods.
- Continued research is part of the solution.

Anisogramma anomala

- **Through a long-term study from 2003-2009, we have concluded that pathogenic variation exists in *A. anomala*.**
- **EFB isolate populations were collected from:**
  - New Jersey – 2
  - New York – 3
  - Pennsylvania – 3
  - Massachusetts – 1
  - Minnesota – 2
  - Michigan – 1
  - Oregon - 1

- **After being exposed to all of the isolates, only 5 of 12 "resistant" cultivars showed no signs of EFB infection.**

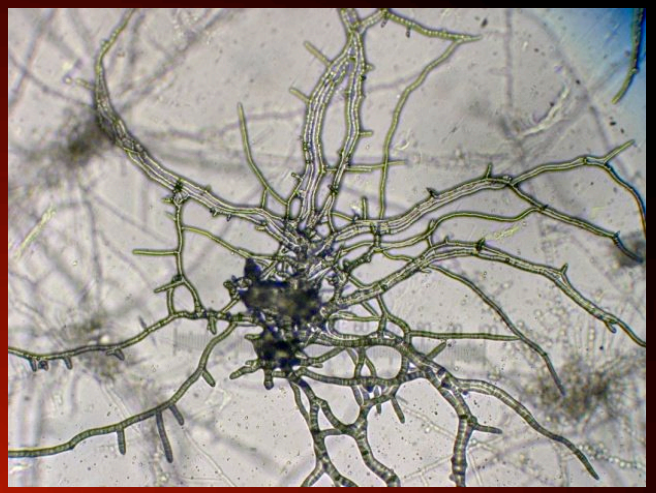
Anisogramma anomala

- Further genetic research is being conducted on *A. anomala*.
- A draft sequence of the *A. anomala* genome has been assembled, and we are beginning to develop molecular markers to asses isolates of the fungus.
- More isolates are being collected, from the previous sites and more, including Wisconsin, Maine, Indiana, and Ohio.
- These isolates are being cultured, after which DNA will be extracted from them, and the markers will then be used to determine their relatedness.

Germinating *A. anomala spores*

Anisogramma anomala

- Understanding the fungus better, identifying different races, and determining how they interact with resistance genes will allow us to gain a more durable resistance in future progeny.
- Hazelnut orchards can be in production for 60-70 years, so resistant plants that will offer a long-term solution are needed.
- Fungi can evolve and adapt, so understanding as much as we can about the pathogen will help insure successful plant breeding.
- Breeding is an important objective, but ongoing research is necessary. Both are aspects that we value in our program at Rutgers.



A. anomala culture at 8 weeks

Key Points

- Recognize the fungus and employ screening techniques in both breeding programs and orchard cultivation.
- Use whatever effective treatments exist to manage the disease, including growing resistant cultivars.
- Continue to search for novel sources of disease resistance and pyramid the genes through breeding for a more durable resistance to EFB.
- Research and study the disease and the plant-pathogen interaction to learn more about the fungus, its behavior, and modes of resistance that can be used in ongoing breeding work.

Questions?