Hazelnuts: A New Sustainable, Low-input Crop for the Eastern United States

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Hazelnuts: *Corylus* spp.
World production is based on the European hazelnut, *Corylus avellana*. Several other species with smaller nuts are native to North America and are useful for breeding better adapted plants.
Hazelnuts – some background

- Called hazelnut or filbert
- Hazelnuts are the 5th most important tree nut crop in the world (748,000 MT/yr) behind cashews, almonds, walnuts, and chestnuts
- Current commercial production centers are restricted to areas with climates moderated by large bodies of water
- The U.S. produces around 4% of the world crop, behind Turkey (70%) and Italy (18%)
- 99% of the U.S. hazelnut crop is grown in the Willamette Valley of Oregon

Current world production regions - Corylus avellana
Hazelnuts naturally grow as a large bush, but are pruned to a single trunk in the U.S. to facilitate mechanical harvesting.

- In Italy and Spain, trees are pruned to a single trunk or several stems and are mechanically harvested.
- In Turkey, hazelnuts remain multi-stemmed, are planted in clumps, and are hand harvested.
Hazelnuts and their Culture

- U.S., Italian, and Spanish cultivars drop their nuts from the husk when mature
  - mechanically harvested from orchard floor
- Turkish cultivars clasp the nuts in the husk to facilitate hand harvesting
- Nuts are sold in shell (5-10% of world crop) or as kernels for use in candies and other products
Hazelnuts typically flower in mid to late March.

- Wind pollinated
- Monoecious
- Self-incompatible (sporophytic)
Male (staminate) flowers (catkins)
Female (pistillate) flowers
*Nuts develop in a leafy husk of varying shape and size

*Nuts ripen from late August to late September depending on the cultivar
100+ year old *Corylus avellana* over 30 feet tall

Wild *C. americana* is more shrubby and spreading, reaching 10-20’
Hazelnut near Passion Puddle on Cook Campus infected with eastern filbert blight
8 year old European plant pruned to a single trunk

In Oregon, single trunk trees are traditionally spaced on 20’ centers (‘Barcelona’ x ‘Daviana’)

Some newer plantings using smaller statured cultivars are 20’ between row and 10’ in rows

Layered or grafted trees begin to bear nuts in 3-4 years, with good production by 7 or 8
History of Hazelnuts in Eastern North America

- Early colonists brought hazelnuts from Europe – very few records, no production established
- The fungal disease Eastern Filbert Blight killed most European hazelnut trees
- Disease is naturally occurring on the wild American hazelnut, *Corylus americana*
- EFB is the **primary reason** no commercial hazelnuts are grown in the east

Native range of wild American hazelnut and associated pathogen *Anisogramma anomala* that causes Eastern filbert blight (EFB)
Most European hazelnuts are highly susceptible
Fungus grows under bark
When reproducing, it creates cankers that kill the trees
Ornamental Contorted hazelnut: Very susceptible to EFB
While some European cultivars can be killed outright from cold temperatures, most cold injury occurs to male flowers (catkins).

Interestingly, female flowers are very cold hardy.
Hazelnuts were first brought to the Pacific Northwest in the late 1800s by nurseryman Felix Gillet.

European cultivars were well adapted to the climate of the coastal valleys of Oregon and Washington and no eastern filbert blight was found there.

Hazelnut industry thrived for nearly 100 years, until...
EFB was found in southwest Washington in the 1960s. Orchards consisted of highly susceptible cultivars leading to major EFB epidemics and orchard destruction and loss in Washington and Oregon. Fortunately, prevailing weather patterns slowed the spread southward in the valley; however, EFB can now be found throughout the entire Willamette Valley.

http://oregonstate.edu/dept/botany/epp/EFB/location/map1.htm
Finally, Eastern Filbert Blight Research!

- Research at Oregon State Univ. was initiated soon after EFB was discovered in Washington.
- This resulted in a much greater understanding of the biology, lifecycle, and control of EFB.
- Control included disease scouting, pruning, and applications of fungicides.
- However, hazelnuts are traditionally a low input crop— the use of resistant cultivars would be the most optimal means for control.

http://oregonstate.edu/dept/botany/epp/EFB/lifecycle.htm

Lifecycle of Anisogramma anomala
http://oregonstate.edu/dept/botany/epp/EFB/
Breeding EFB Resistant Plants

- Searching for resistance to EFB began at Oregon State Univ. in the 1970s, including means to better identify resistant plants.
- From this work, ‘Gasaway’ (the first), and later many other sources of resistance (and tolerance) to EFB have been identified.
  - Finally, new EFB resistant cultivars released in Oregon in 2005 (‘Santiam’, ‘Jefferson’).
- We have been capitalizing on these advances at Rutgers.

Greenhouse inoculations with *A. anomala* to identify resistant seedlings.
Sources of EFB Resistance

- Working closely with Oregon State University, we have obtained nearly 15 unrelated sources of genetic resistance to EFB
  *Corylus avellana, C. americana, C. colurna, and C. heterophylla*
- We also identified new EFB resistant seedlings from our own germplasm collection efforts in Russia and Crimea
- These resistance sources are being used in the breeding program to create improved resistant new cultivars


Russian hazelnut seedlings showing no EFB after 8 years of high disease pressure!
Rutgers Breeding Program:

- Started in 1996, we now has over 18,000 germplasm accessions and breeding progeny under evaluation in the field and greenhouse and the collection is rapidly growing.
Diverse untapped *Corylus* genus available for breeding!

European hazelnut, *C. avellana*, native range

Wild American hazelnut, *C. americana*, native range

There are 10+ hazelnut species, including several widespread in China!
Breeding Improved Hazelnuts for the Northeast – EFB no longer a limiting factor!

Breeding Priorities:
- 1. EFB resistance and good overall plant health
- 2. Medium to large size round nuts with high quality kernels (over 1.0 g and kernel percent near 50% or higher)
- 3. Cold hardy, late-flowering catkins
- 4. Precocious (early bearing) and high yielding

Hybridize superior unrelated parents with desired traits that compliment each other’s shortfalls, i.e.
- Disease resistant and cold hardy, but with poor quality nuts
- Disease susceptible and cold-sensitive, but with large, high quality nuts

Diverse sources of resistance to Eastern Filbert Blight are being incorporated into advanced generation hybrids
Complimentary Hybridization may include interspecific hybridization

**Corylus americana** Minnesota
12-15 nuts per cluster
EFB resistant, female

**C. avellana ‘Syrena’** Poland
2-3 nuts per cluster
EFB susc., purple leaves
male

Disease resistant and cold hardy offspring from controlled cross made in 2001

**GHR11P4**
3-5 nuts per cluster
44.2% kernel, EFB resistant

Used as a parent in 2nd generation crosses made in 2007-2009
• Make controlled crosses in March --harvest seed in August
• Germinate seed and plant hybrid seedlings in field the following year (3,000 per year)
• EFB inoculations are done in greenhouse and field to infect trees early and maintain high disease pressure
• Trees are not sprayed for pests or diseases. Inputs are limited to yearly fertilizer and weed control and irrigation in year 1
From field inoculations, EFB starts to be visible in year 3

No plants are removed to let the epidemic develop
By artificially maintaining disease pressure, in year 5 susceptible trees are clearly evident or already dead. At this time nuts are being produced.
Goal is to identify EFB-resistant, late-flowering, healthy and vigorous plants by the year the first nuts are produced.
Healthy plants are identified, sick ones are removed.
Nut are collected only from healthy plants starting in year 5.
In year 5 we evaluate nut characteristics of only the healthy, productive trees
   - size, shape, kernel weight, percent kernel, etc.

Those with poor quality nuts are discarded as soon as it is evident
   - Small, long nuts, kernel defects, etc.

We evaluate nuts again in year 6, 7 and 8 if they meet size and quality standards in year 5 and remain EFB resistant

Promising EFB resistant Rutgers hybrid with large nuts
We maintain very high disease pressure into years 6 and 7 by tying diseased wood into each tree.
By year 7 only the best healthy trees with large, round nuts and high quality kernels remain.
These are propagated for replicated yield trials and/or used in next generation of crosses
New selections under evaluation.

Hazelnut clones cannot be grown from seed and must be grafted or layered, like apples.
Are our selections high enough yielding (consistently) and of high enough quality for commercial use?

We are growing these plants at a number of different locations to find out.
Besides what cultivars to grow, many other questions need to be answered for production in the east --

- Timing of flowering a concern in areas with widely fluctuating winter and spring temperatures
  - A series of cultivars, including pollinizers, is likely needed with different flowering times
- What is the most appropriate plant architecture and orchard design?
  - Single-trunk trees or multi-stemmed shrubs
  - Spacing in field like Oregon (20’ x 20’)
  - Grow as high-density hedges?
- What is most appropriate harvesting method?
  - Sweep nuts from orchard floor
  - Develop picking machine that goes over top of bushes?
Hazelnuts show much promise for the future

- While a number of questions still need to be answered and specific plants proven, we have all the pieces of the puzzle needed to breed for well-adapted, productive plants.
- By incorporating natural genetic resistance to pests and disease, hazelnuts will need very few sprays and inputs for production.
- Hazelnuts can grow on poor and sloping soils, and are a healthy food, with a large market that has room to grow.
  - Plus, other markets exist for oils, shell products and wood, etc.
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