# Blueberries

## Making a Superb Fruit Even Better!

When U.S. Department of Agriculture botanist Frederick Coville started the world's first successful blueberry breeding program, did he envision it would grow into the multi-million dollar industry it is today? Maybe. But a century later, thanks to dedication by Coville, collaborator Elizabeth White, and other USDA and university scientists, blueberries are the second most popular berry consumed in the United States.

A member of the genus *Vaccinium,* blueberries are related to many commercially important and popular fruit species, like cranberry, lingonberry, and huckleberry. Blueberries are mainly native to North America and are lauded for their health benefits.

PEGGY GREB (D2182-1)

Plant geneticist Mark Ehlenfeldt (left) and plant pathologist James Polashock examine blueberry plants and collect data on mummy berry fruit infection to evaluate resistance.

Coville began researching blueberries in 1906, when he started a series of experiments to learn fundamental facts about them, thinking they might be suitable for cultivation. Coville found that blueberries and many other plants require acid soils to grow, a fact not known to horticulturists prior to his experiments.

After a few years of study, Coville published in 1910 the first bulletin outlining how to successfully grow blueberries from seed to fruit. White, whose family at that time had a successful cranberry farm in New Jersey, helped Coville acquire some of the best wild blueberry plants to use as parents in his breeding experiments.

In 1911, Coville made the first cross of wild blueberry germplasm that eventually led to the release of several blueberry cultivars—ancestors of cultivars currently grown throughout the world—marking the beginning of USDA's current breeding program.

Throughout the years, notable Agricultural Research Service blueberry breeders George Darrow, Donald Scott, and Arlen Draper have made significant contributions to the advancement of blueberries. Today, 100 years after Coville made his first successful cross, ARS researchers throughout the country continue the longstanding goal of improving blueberries so consumers can enjoy them for many more centuries to come.

### Mitigating Mummy Berry Blight and Fruit Rot

Geneticist Mark Ehlenfeldt and plant pathologist James Polashock are researching mummies—mummified blueberries, that is, which got that way because of a disease. The scientists are with the Genetic Improvement of Fruits and Vegetables

Laboratory in Beltsville, Maryland, and are stationed at the Philip E. Marucci Center for Blueberry and Cranberry Research and Extension in Chatsworth, New Jersey. One of ARS's flagship locations for blueberry research, Chatsworth houses the largest collection of potted and in-ground blueberry cultivars in the world.

In addition to releasing improved blueberry varieties, the researchers focus on screening for disease resistance, and mummy berry is one of the most important blueberry diseases in North America.

"Mummy berry is caused by the fungus *Monilinia vaccinii-corymbosi*," says Polashock. "It occurs almost everywhere blueberries are grown and affects all cultivated species, including highbush, lowbush, rabbiteye, and some wild species."

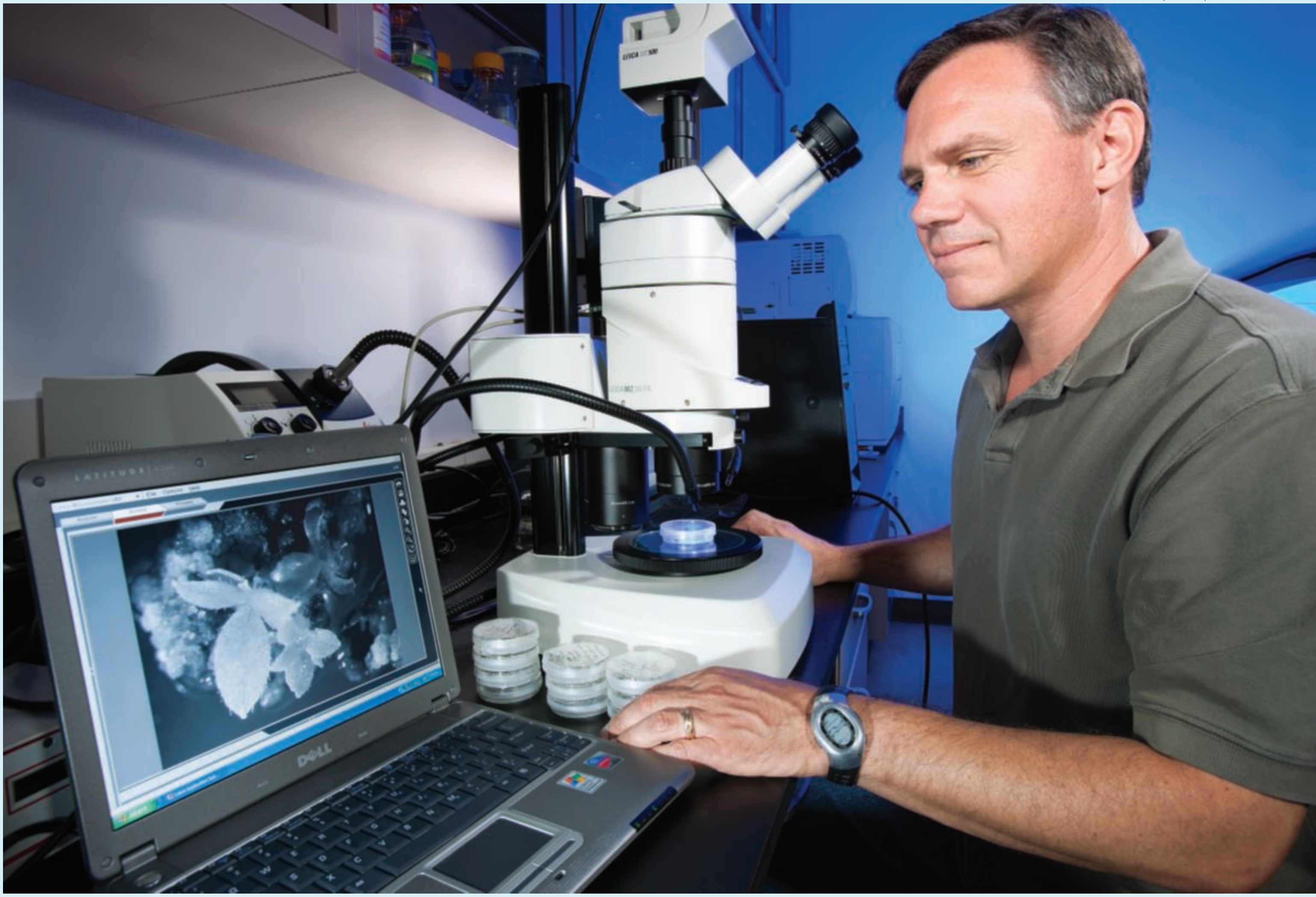
Mummy berry disease is unique because it occurs in two distinct phases. During the blighting phase, small, cup-shaped structures bearing fungal spores sprout from mummified berries concealed in leaf litter on the ground. Wind spreads the spores to blueberry plants, infecting the newly emerging shoots and leaves. A second phase of spores, produced on blighted tissue, is carried by bees to the flowers, beginning the fruit-rotting stage. During this phase, the fungus fills the inside of the blueberry as it grows and causes it to shrink, shrivel, and turn whitish—hence the mummy reference. The mummified fruit drops to the ground and overwinters, waiting to begin the process again in the spring.

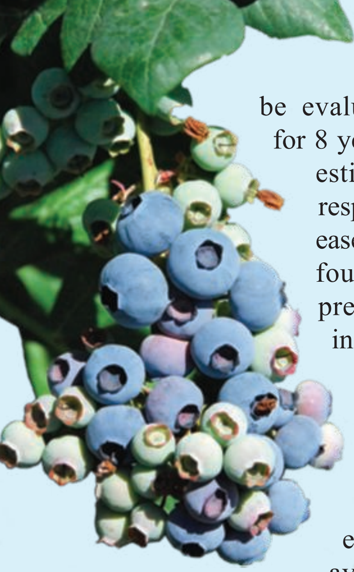
In an effort to mitigate this disease, Ehlenfeldt, Polashock, plant pathologist Allan Stretch (now retired), and statistician Matthew Kramer undertook two long-term, simultaneous studies examining cultivar response. The first study, published in the scientific journal *HortScience,* sought to predict cultivar resistance and susceptibility to both phases of the disease. The scientists examined more than 90 blueberry cultivars over 9 to 12 years.

"We found that disease response had significant and large genotype-by-environment interactions," explains Ehlenfeldt. "This means that the 2-3 years of data typically used for publication aren't enough to reliably estimate disease resistance. Breeders should

James Polashock screens blueberry tissue cultures for plantlets that have transformed, or changed, their genetic makeup. These plantlets are easy to identify because they express a green fluorescent protein and glow under UV light in the procedure being used. In these transformed plantlets, the genes that respond to the fungus that causes mummy berry are likely to provide clues to resistance to the disease.

PEGGY GREB (D2181-1)





be evaluating resistance for 8 years to get a good estimate of cultivar response to this disease." The researchers found an important predictor of blighting to be either the average amount of precipitation at the end of January or rain frequency at the end of March. The average high temperature in late February was predictive for the fruit-infection phase.

Despite predictions of needing 8 years to estimate disease resistance, a second study, also published in *HortScience,* analyzed data from 125 cultivars tested for 2-6 years for resistance to the blighting phase and 110 cultivars tested for 2-5 years for resistance to the fruit-infection stage. Using innovative statistics developed by Kramer, the researchers were able to rank resistances among the wide range of cultivars. "For breeding, one often needs only to know which cultivars are the most resistant on a relative basis," says Ehlenfeldt. They found several cultivars, such as Brunswick and Bluejay, to be resistant to both phases of mummy berry infection.

"Ultimately, documentation of resistance to each phase will help growers select which cultivars to plant," says Ehlenfeldt. "This will also help breeders develop strategies to produce cultivars with superior resistance."

**Preventing Fruit Splitting**

The Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi, joined ARS's blueberry research program in the 1970s. Led by horticulturist James Spiers (now retired), the program was started after the region's tung oil industry collapsed because of competition from imported petroleum and a devastating blow from Hurricane Camille in 1969. "Rabbiteye blueberries are native to the Southeast," says Spiers. "ARS has also introduced a southern highbush blueberry to the region. Combined, the two blueberry species have proven to be a viable specialty crop for this area."

So far, Poplarville scientists have released 15 cultivars for growers in the Southeast. But that's not all they do. The researchers also focus on solving problems growers face, such as rain-induced fruit splitting.

"Splitting and cracking occur in southern highbush and rabbiteye blueberries if they receive preharvest rainfall when fully ripe or approaching ripeness," explains horticulturist Donna Marshall. She works with Spiers, geneticist Stephen Stringer, and University of Southern Mississippi associate professor Kenneth Curry on this problem. "Researchers have studied rain-induced splitting in cherries, grapes, and tomatoes, but it hasn't been explored in blueberries."

Splitting can be mild, in the form of a shallow crack in the skin, to severe, such as deep wounds that penetrate the pulp. But regardless of severity, all splitting renders the fruit unmarketable. Growers in Mississippi and Louisiana have reported as much as 20 percent crop loss on highly susceptible cultivars. That amounts to losses of $300 to $500 per acre.

The researchers examined several aspects of fruit splitting in three studies published in *HortScience.* In the first study, published in 2007, the researchers developed a laboratory method to model rain-related splitting in blueberries. Many breeders throughout the country are using this method to more vigorously screen cultivars and selections for splitting susceptibility. The results from field and

PEGGY GREB (D982-1)

Horticulturist Donna Marshall measures blueberry firmness to determine the correlation between fruit firmness and susceptibility to fruit splitting.

laboratory tests showed that the rabbiteye cultivar Premier had the lowest incidence of splitting while widely grown cultivar Tifblue exhibited a high incidence of splitting.

Marshall and colleagues also investigated the correlation between splitting susceptibility and fruit firmness. Laboratory and field tests proved that, in general, firmer fruit has a higher tendency to split. But one selection, named "MS614," exhibited extreme firmness and splitting resistance. The results, published in 2008, suggest that breeders who select for firmness may inadvertently also be selecting for splitting. But the laboratory screening method Marshall and colleagues created has helped remedy this problem.

The most recent study, published in 2009, evaluated water-uptake thresholds in split-resistant Premier and split-susceptible Tifblue fruit at all stages of development. The researchers harvested and weighed the fruit, then soaked it in distilled water at room temperature for 24 hours. They found that Premier absorbs more water than Tifblue yet remains intact and experiences minimal splitting.

"Through our studies, we've shown that splitting is a cultivar-specific problem," says Marshall. "But there are still questions, such as what is going on at the cellular level that allows a cultivar to stay intact? With further research, we hope to find the answer."

**Generating Genomic Tools for Blueberry Improvement**

Geneticists Chad Finn, with the ARS Horticultural Crops Research Unit, and Nahla Bassil, with the ARS National Clonal Germplasm Repository—both in Corvallis, Oregon—are developing and

An example of rain-induced splitting, a problem that can lead to losses of up to 20 percent on highly susceptible cultivars.


CARRIE WITCHER (D2194-1)

# Blueberries of the World Housed in Unique Collection

Blueberries from throughout the United States—and more than two dozen foreign countries—are safeguarded at America's official blueberry genebank. Located in Corvallis, Oregon, this extensive living collection includes domesticated blueberries and their wild relatives, carefully maintained as outdoor plants, potted greenhouse and screenhouse specimens, tissue culture plantlets, or as seed.

The genebank's purpose is to ensure that these plants, and the diverse gene pool that they represent, will be protected for future generations to grow, study, improve, and enjoy. Plant breeders, for example, can use plants from the collection as parents for new and even better blueberries for farm or garden.

Blueberries and several other berries are among the fruit, nut, and specialty crops housed at what's officially known as the ARS National Clonal Germplasm Repository-Corvallis. The repository is part of a nationwide, ARS-managed network of plant genebanks.

Likely the most comprehensive of its kind in the world, the blueberry collection nevertheless continues to expand, according to research leader Kim E. Hummer. Some acquisitions, referred to as "accessions," are donations from breeders. Others are acquired through collecting expeditions, which have taken plant explorers to, for example, Russia, China, Ecuador, and Japan, as well as throughout the United States.

"We have focused on collecting blueberry relatives that may have immediate use for U.S. breeders," says Hummer. "For example, we've acquired native species of wild blueberries from the Pacific Northwest that bear fruit with pigmented flesh, or pulp. Some breeders are trying to breed some of these species into the familiar highbush blueberry that has a white interior. If breeders can put color on the inside of berries through crossbreeding the internal-color berries with the highbush plant, they may be able to produce a blueberry that gives fuller color to processed blueberry products, such as jams, jellies, juice, and dried or frozen fruit."

Other prized specimens at the genebank may someday become landscaping favorites. "We have *Vaccinium praestans,* or redberry Kraznika, from Russia, China, and Japan," says Hummer. "It's low growing and is called 'rock azalea' in Japan. This red-fruited berry plant is suitable for northern latitudes and would be an interesting and attractive ground cover that comes complete with edible fruit." —By **Marcia Wood,** ARS.*

*Kim E. Hummer is with the USDA-ARS National Clonal Germplasm Repository, 33447 Peoria Rd., Corvallis, OR 97333; (541) 738-4201, kim.hummer@ars.usda.gov.*

CHAD FINN (D2195-2)

CHAD FINN (D2195-3)

ARS researchers in Corvallis, Oregon, are developing and improving blueberries for the Pacific Northwest. Above are Elliott blueberry plants in full bloom. Inset: Close-up of blueberry flowers.

improving blueberries for the Pacific Northwest. Although Corvallis is the most recent ARS location to conduct blueberry breeding, Finn and Bassil are playing an important role in a nationwide, multi-institutional project aimed at developing genomic tools to help improve blueberries.

Funded by the Specialty Crops Research Initiative, the project is led by fellow ARS geneticist Jeannie Rowland in Beltsville, Maryland, and involves several university and international collaborators. Finn and Bassil are working with Michigan State University professor James Hancock in developing a genetic map for highbush blueberry.

"We are currently testing plants made from a cross between the northern highbush cultivar Draper and the southern highbush cultivar Jewel at various locations across the country where blueberry is grown," says Finn. "Our task is to compare the performance of each plant in the field. For the next couple of seasons, we will evaluate the plants for chilling requirement, cold tolerance, and fruit-quality traits."

In the lab, Bassil is processing leaf samples to extract DNA and genotype the plants. The researchers will then merge the field and lab data to determine whether genetic markers that predict a plant's performance can be identified. Bassil is also helping to develop genetic markers and following them through mapping populations and wild blueberry populations for genetic diversity studies.

The new tools, once available, should make blueberry breeding and cultivar development far more efficient.—By **Stephanie Yao,** formerly with ARS.

*This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement (#301), Plant Diseases (#303), and Crop Production (#305), three ARS national programs described at www.nps.ars.usda.gov.*

*To reach scientists mentioned in this article, contact Robert Sowers, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1651, robert.sowers@ars.usda.gov.* ✻

Fruit cluster of Draper, a cultivar released by Michigan State University and named in honor of Arlen Draper, a long-time blueberry breeder with ARS in Beltsville, Maryland.

CHAD FINN (D2195-1)