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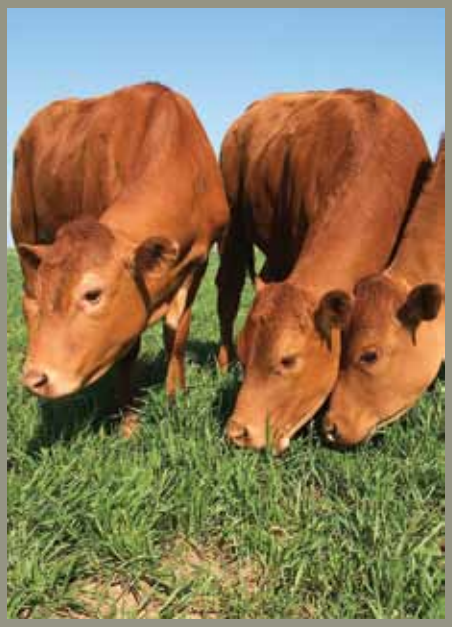
Agricultural Research Service

Mid South Area Fiscal Year 2010-2012 Research Highlights







Foreword

In the pages that follow, you will find articles about the work of the Agricultural Research Service (ARS) in the Mid South Area. The Mid South Area is one of eight ARS Areas. We have a diverse workforce of over 700 employees, including more than 220 research scientists, who work in 10 research locations in Mississippi, Louisiana, Alabama, and Kentucky, as well as 2 worksites in Tennessee and Arizona. Our Area Office is located in Stoneville, MS, in the Jamie Whitten Delta States Research Center.

ARS is the research arm of the U.S. Department of Agriculture. It is responsible for solving problems of national importance. Because ARS is a problem-solving agency, our research is results-oriented and product-driven. Through new knowledge and the development of new and improved technology, we work hand-in-hand with our State university partners, stakeholders, and other U.S. Government agencies to meet the agricultural, nutritional, and environmental demands of our customers. We work to create technologies and scientific discoveries to mitigate world hunger and ensure a nutritious, safe food supply, including research in peanut and tree nut allergy. Revitalization of rural America through agricultural research that strengthens the agricultural economy is a goal of ARS.

Many of the broad areas where we concentrate our research attentions are familiar to you. They include crops traditionally associated with the South—like cotton, sugarcane, soybeans, rice, corn, ornamental plants, and small fruit. Increasing the efficiency of producing catfish, cattle, and poultry is also a research focus, as are honey bee health and the use of honey bees for crop pollination and honey production.

You will read about recent efforts to protect crops from weed, insect, and microbial pests; new plant and animal germplasms that are pest resistant; and the release of small fruit varieties, such as blueberry with unique nutriceutical properties. You will also read about efforts to improve the competitive advantage of U.S. cotton producers by improving fiber quality, by making cotton ginning more efficient, and by developing value-added products from cotton fiber and seed.

You will also learn about our efforts to be effective stewards of our land—through measuring the carbon footprint of various cropping systems, preventing erosion, keeping groundwater available and clean, and developing conservation management practices that economically aid producers while safeguarding the environment. Other environmentally sustainable research includes the use and encouragement of natural enemies to biologically control pests, and the growing and testing of “energy” crops for ethanol production from cellulose to supply the energy needs of our growing population.

A list of our research units and labs, along with their contact information, is provided in the back of this volume. Please let us know if we can be of service to you.

Edgar G. King, Director
Archie Tucker, Assistant Area Director

The articles in this volume are reprinted from *Agricultural Research* magazine, which is published by the U.S. Department of Agriculture, Agricultural Research Service, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; phone (301) 504-1651. The magazine is available on the Internet at ars.usda.gov/ar.

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Cover: The broad scope of scientific efforts in the Mid South Area includes research on (front cover) blueberries, sugarcane, bees, catfish, corn, chickens, cows, (back cover) channel geometry and stream corridor habitats, cotton, plant bugs, soybean, pigweed, and fire ants.

New Blueberry Varieties Being Readied for Sale

Blueberry growers and consumers alike stand to benefit from Gupton and Pearl, two new southern highbush cultivars developed by Agricultural Research Service researchers in Poplarville, Mississippi. In addition to high yields of plump, flavorful berries and vigorous growth, the new cultivars should give southern growers a jump on the lucrative early-ripening fresh market, which starts in April and May.

"There's been limited acreage of southern highbush blueberries because their lack of vigor has made them difficult to grow. However, we've overcome that problem to a large extent by developing hybrids from crosses made among southern highbush germplasm showing greater adaptation to the southeastern United States," says Stephen Stringer, a geneticist at ARS's Thad Cochran Southern Horticulture Laboratory in Poplarville.

Gupton and Pearl, released in 2006 and 2010, respectively, are finding their way into crop fields and nurseries as more propagative material becomes available from tissue-culture operations and softwood cuttings.

"Several nurseries have requested Pearl, and there are some growers in Mississippi who have Gupton in small plots in their fields. Gupton's also being evaluated in some trials in North Carolina and other southern states and is looking very good," reports Stringer. He collaborated on the cultivars' development and testing with ARS horticulturists Donna Marshall and James Spiers (retired) and ARS small-fruits breeder Arlen Draper (retired).

Southern production of blueberries, both for fresh and frozen (processing) markets, is situated in the Gulf Coast states of Mississippi, Florida, Alabama, and Texas, and the Carolinas and Georgia. In 2002, for the first time, consumer demand for fresh blueberries overtook that of frozen blueberries nationwide and has since retained its lead, with Americans consuming 1.1 pounds per person in 2010 versus 0.6 pounds for frozen berries.

STEPHEN STRINGER (D2583-1)

Prince, an early-ripening rabbiteye blueberry released by ARS.

Michigan, Maine, New Jersey, and other northern states lead U.S. cultivated blueberry production, valued at nearly $590 million, but year-round demand for the antioxidant-rich fruit has given southern growers a chance to enter the fray, especially the early-ripening fresh market. Gupton and Pearl are the latest southern highbush blueberries to emerge from the Poplarville program with that market squarely in mind, says Stringer. Prior to release, both cultivars underwent several years of field evaluation in south-central Mississippi for vigor, yield, berry quality, splitting resistance, and other traits.

In trials, Gupton and Pearl flowered in mid to late March and were ready for harvest about 21 days before the earliest ripening rabbiteye cultivars, which have been the predominant type grown in the South. Gupton and Pearl produce medium to large, flavorful berries with light-blue color and a high soluble-solids content. The cultivars grow as sturdy, upright shrubs and have a chilling requirement (necessary for springtime blooms) of 400 to 500 hours at temperatures below 45°F.

In addition to the highbush releases, the Poplarville team is readying specialty cultivars for various niche markets, including U-pick farms and bakers, and cultivars with jumbo-sized berries weighing nearly 5 grams.

"We also released Prince, an early-ripening rabbiteye that can be harvested 7-10 days sooner than existing rabbiteyes," adds Stringer.—By **Jan Suszkiw,** ARS.

REGGIE DAVIS (D2582-1)

Geneticist Stephen Stringer examines a rabbiteye blueberry (selection MS1262) that will soon be released. He and collaborators have developed new varieties of southern highbush and early-ripening rabbiteye blueberries.

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

Stephen Stringer and Donna Marshall are with the USDA-ARS Southern Horticulture Research Laboratory, 810 Hwy. 26 West, Poplarville, MS 39470; (601) 403-8768 [Stringer], (601) 403-8762 [Marshall], stephen.stringer@ars.usda.gov, donna.marshall@ars.usda.gov.

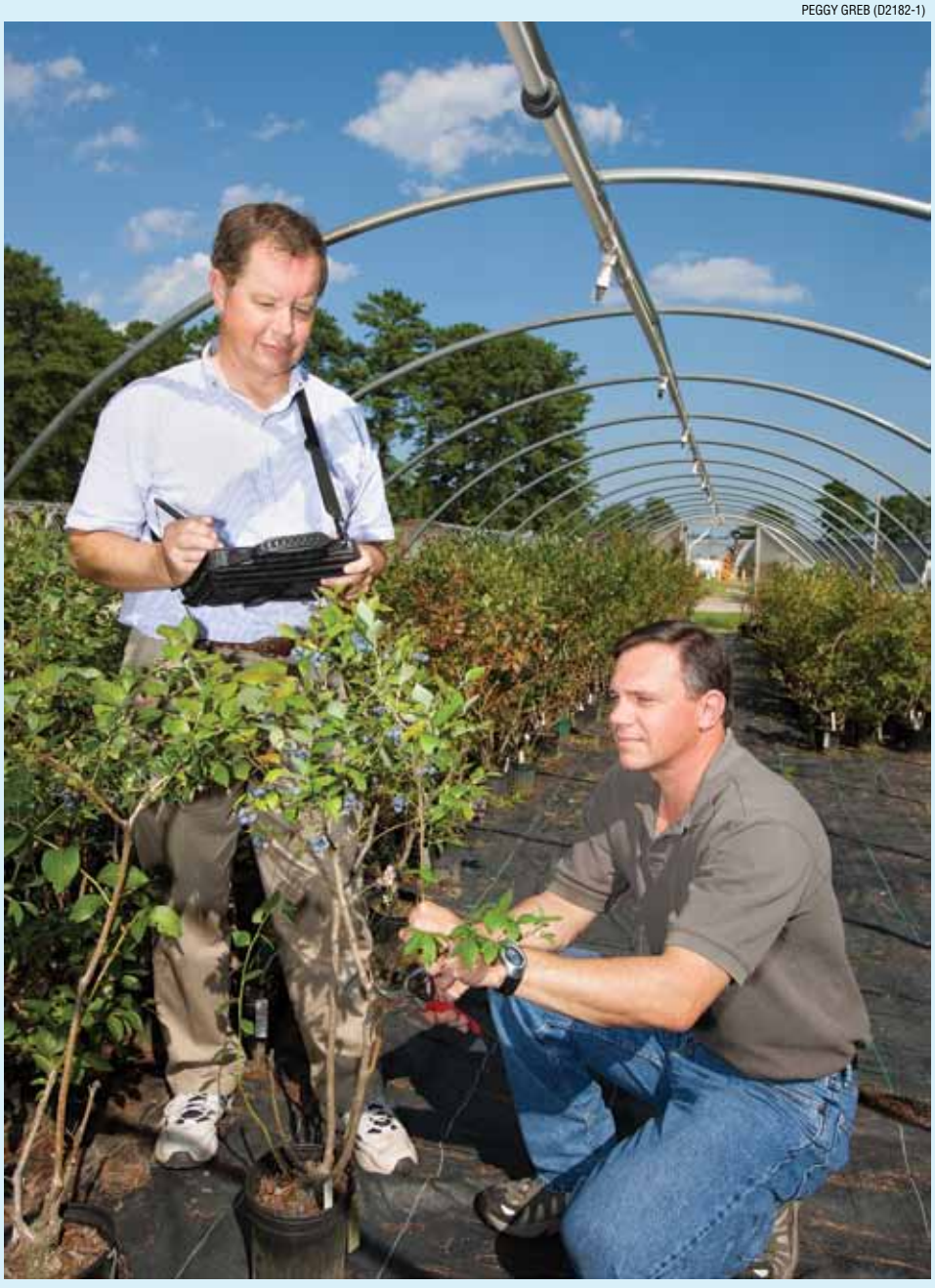
Blueberries

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."

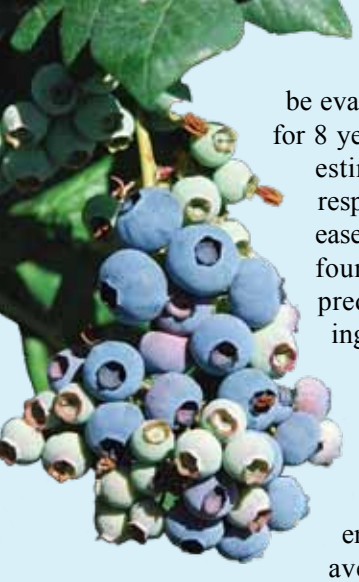
Mummy berry disease is unique because it occurs in two distinct phases. During the blighting phase, small, cup-shaped structures bearing fungal spores sprout from mummified berries concealed in leaf litter on the ground. Wind spreads the spores to blueberry plants, infecting the newly emerging shoots 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.

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)

ARS Overseas Lab Sets the Stage for Reuniting a Weed and Its Enemies

The search is on for insects, mites, microbes, or nematodes that could nibble on, gnaw through, or sicken silverleaf nightshade in a biologically based approach to controlling this noxious weed, which hails from the Americas but has spread to southern Europe, Africa, India, Australia, and elsewhere.

Among other harm it causes, the purple-flowered perennial weed *Solanum elaeagnifolium* outcompetes native plants, reduces crop yields, and diminishes pasture productivity. Its toxin-containing orange berries can also poison livestock. Chemical and mechanical controls like mowing sometimes work against the weed. But severe infestations can render such controls too costly, impractical, or environmentally harmful to use repeatedly.

Biocontrol is considered sustainable because it involves releasing select natural enemies of the weed that will feed or develop on it exclusively and continue doing so until their host is reduced in numbers toward the natural balance that existed in its native range.

"Typically, these biological control agents are insects that severely damage or kill the weed, leave useful plants alone, and restore the ecological balance between the weed and its environment," explains Walker Jones, who, in April 2010, completed a 5-year assignment as director of the Agricultural Research Service's European Biological Control Laboratory (EBCL) near Montpellier, France.

Before returning stateside to lead ARS's National Biological Control Laboratory in Stoneville, Mississippi, Jones and ARS national program leader Daniel Strickman established a cooperative project with the Benaki Phytopathological Institute in Athens, Greece, to explore the feasibility of starting continental Europe's first-ever classical weed-biocontrol program.

Normally, EBCL serves as a sort of way station, where promising biocontrol agents collected from Europe, Asia, or Africa are screened for potential release into the United States to manage invasive species. But in this instance, the lab will switch gears—serving as a receiving point for candidate organisms from North America that could open the door to biologically controlling infestations of the weed in Greece and other countries in the Mediterranean basin, where effective native natural enemies have yet to be tested.

The first stages have already begun. At Montpellier, EBCL molecular biologist Marie-Claude Bon is using DNA-based methods to analyze the genetic diversity of silverleaf nightshade populations collected from sites in the southwestern United States, Argentina, Greece, France, and Australia. Her analysis will help to determine the weed's center of origin and trace the route of its world invasion.

"This, in turn, will pinpoint where to locate co-evolved natural enemies," says Jones. Once identified, they'll be sent to Montpellier and rigorously tested under quarantine to ensure their host specificity and safety as biocontrol agents intended for release.

First, however, a survey of Greece's weed populations must be completed. "After processing these data, we're hoping to use satellite photos to have a precise map of silverleaf nightshade populations and densities in various areas of Greece," says Javid Kashefi, an EBCL entomologist stationed at the American Farm School in Thessaloniki.

"This weed very likely came from the southwestern United States and northern Mexico," says Jones. "We wanted to use EBCL's unique experience, location, and facilities to establish a biocontrol project that would benefit Europe—sort of as thanks for the biocontrol agents we've acquired and sent to the United States for the past 90 years." There's also keen interest for similar projects in North African countries where silverleaf nightshade is the top weed pest, he adds.—By **Jan Suszkiw,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

Walker Jones is with the USDA-ARS National Biological Control Laboratory, 59 Lee Rd., P.O. Box 67, Stoneville, MS 38776; (662) 686-5487, walker.jones@ars.usda.gov. ✻

Silverleaf nightshade *(Solanum elaeagnifolium).*

WHOLE TREE A More Sustainable,

Fresh WholeTree chips being processed into a substrate component at Young's Plant Farm.

A worker at Young's Plant Farm transplants seedlings into containers filled with an experimental substrate containing WholeTree.

At Young's Plant Farm in Auburn, Alabama, rows of southern pine trees *(Pinus taeda)* stretch as far as the eye can see. But these trees won't be used to decorate landscapes and parks or to provide shade on a hot day. Instead, these pine trees—commonly known as "loblolly pine"—will be used to grow the vibrant, healthy potted plants we see in nurseries and garden centers.

Nursery plants are grown in containers filled with a soil-less potting media, formally called "substrate," which typically consists of Canadian peat moss, perlite (heat-expanded volcanic rock), vermiculite (heat-expanded silicate mineral), and pine bark. But the process of harvesting, preparing, and shipping peat moss, perlite, and vermiculite requires tremendous energy inputs. Also, the availability of pine bark has been tenuous because it depends on the stability of various other industries from which pine bark is derived.

Seeing this predicament, horticulturist Glenn Fain, formerly with the ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi, and Charles Gilliam, a professor at Auburn University, began looking for an alternative material to use as a substrate or substrate component. Fain continues to collaborate with Jim Spiers, research leader of the Poplarville laboratory; Anthony Witcher, a doctoral student and horticulturist at Poplarville; and Greg Young, owner of Young's Plant Farm. In 2005 and 2006, ARS, Auburn University, and Young's Plant Farm entered into specific cooperative agreements to develop a new substrate they call "WholeTree."

Locally Produced, Completely Self-Sustainable

As its name suggests, WholeTree is made from all parts of the loblolly pine—bark, needles, wood, and cones. The word "loblolly" means "low, wet place," but these trees aren't limited to that environment. Loblolly pines grow well in acidic clay soil, which is commonly found in the South, and can be found in large

Environmentally Friendly Substrate

groups in rural areas. But trees used to make WholeTree aren't taken from natural areas; they're farmed at tree plantations across the southeastern United States.

The pine trees used are those that are harvested from pine plantations at the thinning stage. "Thinning" is when some trees are removed to achieve a density the site can support. The trees are then chipped and further processed to achieve the desired physical properties needed for a substrate component. Similar products have been available in Europe for several years, but WholeTree could be one of the first available products for the United States made from locally grown materials.

"We've taken a locally available product that's native to this region and that's already being farmed, and we've used it to make a more environmentally friendly product," says Fain, now an assistant professor at Auburn University. "It's completely self-sustainable and would cost less than other substrates on the market."


WAYNE J. MCLAURIN (D1874-1)

Glenn Fain evaluates garden chrysanthemums grown in WholeTree at the ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi.

Field and laboratory studies have demonstrated the successful use of WholeTree, even at 100 percent for some nursery plants. In one study, Fain and colleagues compared chrysanthemums grown in WholeTree with those grown in a WholeTree-and-peat moss mix and a peat moss-and-perlite mix. The scientists collected data on plant growth, flower bud number, leaf chlorophyll content, root rating, shoot dry weight, and nutrient content of plant tissue. In the end, they found minimal differences between the plants, all of which were considered marketable at the conclusion of the study. Other studies have produced similar results with only minor changes in cultural practices.

Results from the studies have been so promising that in 2008, Young's Plant Farm, a supplier to retail outlets such as Lowe's and Wal-Mart, made a significant investment in order to adopt this technology and further the research on a larger scale. They are now producing their own substrate component, farming and harvesting pine trees produced at one of their farms to make WholeTree. In fact, Wal-Mart recently recognized Young's Plant Farm for their efforts with a supplier sustainability award for using the product.

"Other plant suppliers can adopt this technology, although some cultural practices will have to be altered," says Fain. "WholeTree has the potential to be an economically sustainable substrate component that could be available in close proximity to major horticultural production areas throughout the Southeast."

Further Testing and Future Applications

Witcher, Fain, Spiers, and Eugene Blythe, an assistant research professor at Mississippi State University's South Mississippi Branch Experiment Station in Poplarville, are currently conducting further studies evaluating WholeTree's use in cutting and seedling propagation of herbaceous perennial and woody ornamental crops. So far, they have conducted tests on plants popular to the ornamental and landscaping industries, such as the garden mum, perennial salvia, climbing rose, and Leyland cypress.

"We've had promising results, but we need to further examine the physical properties of WholeTree," says Witcher. "We want to create an optimal mix of air space and water-holding capacity in the substrate to enhance root development in these plants. We also want to create a particle size that works well for a wide range of crops."

Researchers are planning to conduct trials using WholeTree as a landscape soil amendment. According to Fain, it is typical practice to add an organic amendment to the soil, especially in heavy clay soils. In the southeast, aged pine bark and peat moss are standard soil amendments. WholeTree will be compared with these standards to determine its potential use in the landscape industry.

Scientists are also planning to conduct plant-growth-response trials at other producer locations in the southeast. And they are looking into the possibility of using other species of trees growing in southern forests as standalone substrates or substrate components.

"We've taken a locally available product that's native to this region and that's already being farmed, and we've used it to make a more environmentally friendly product."
—Glenn Fain

If all goes well, you may soon see plants grown in WholeTree in a nursery near you.—By **Stephanie Yao,** ARS.

This research is part of Crop Production, an ARS national program (#305) described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Stephanie Yao, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1619, stephanie.yao@ars.usda.gov. ✻

Whole-Grain Rice Stakes Out Its Claim

PEGGY GREB (D1734-1)

Research leader Elaine Champagne and chemist Fred Shih discuss sharing the good news of the brown rice health claim while preparing for the Rice Utilization Conference, sponsored by ARS and the USA Rice Federation.

Rice, the staple that supports half the world's population, holds an honored place in the culinary traditions of many cultures. In the United States, appreciation for the grain continues to grow as the population diversifies.

Still, a number of consumers are not aware of the many healthful attributes of rice, and some do not know that brown rice is a whole grain. Another misperception is that the bulk of U.S. rice is imported. U.S.-grown rice actually accounts for about 80 percent of all the rice consumed in America.

Understanding the nutrient content of brown rice is key to appreciating the health benefits provided by these satisfying grains. Importantly, several benefits from consuming whole-grain rice have been made clear lately. Since 2008, brown-rice package labels have been carrying the FDA-approved health claim, "Diets rich in whole-grain foods and other plant foods and low in total fat, saturated fat, and cholesterol may reduce the risk of heart disease and some cancers."

It's not that brown rice only recently joined the whole-grain club. Brown rice has always been a whole-grain food. "Whole grain" is defined as a grain whose bran, germ, and starchy endosperm are intact.

A technical change in the way single-ingredient whole-grain packaged products are monitored for compliance led to an announcement by the U.S. Food and Drug Administration (FDA) about using the whole-grain health claim on the labels of brown rice packages.

Capturing the True Value of Rice

"One reason rice is viewed differently now is that a series of innovative rice utilization workshops led to a better understanding of the health benefits of rice," says Anne Banville, vice president of domestic promotion with the USA Rice Federation, based in Arlington, Virginia. "We have been working with the ARS Southern Regional Research Center (SRRC) in New Orleans, Louisiana, to cosponsor these workshops."

Research leader Elaine Champagne, head of SRRC's Food Processing and Sensory Quality Research Unit (FPSQ), spearheaded seven workshops with the USA Rice Federation during a 16-year period.

The 2007 workshop was inspired by heightened emphasis on daily whole-grain consumption in the 2005 *Dietary Guidelines for Americans.* A consensus statement and plan of action were developed during that workshop that led to the USA Rice Federation successfully petitioning FDA to permit whole-grain brown rice to qualify for the whole-grain health claim.

For compliance purposes, FDA is now using the ingredient statement to assess the appropriate use of the health claim on single-ingredient whole-grain foods.

According to MyPyramid.gov, an interactive tool based on the 2005 *Dietary Guidelines for Americans,* the amount of grains people need to eat depends on their age, sex, and physical activity. MyPyramid.gov encourages males and females aged 9 through 50 and older to consume three "ounce equivalents" of whole-

PEGGY GREB (D1735-1)

Food technologist Harmeet Guraya tests the cooking time of different brown rice varieties. Guraya developed a patented treatment that reduces the cooking time of brown rice to 20 minutes.

grain foods daily, more for males ages 14-50. For many, 1 cup of brown rice provides two-thirds of the minimum recommended daily amount of whole grains.

When only the nonedible hull surrounding a rice kernel has been removed, this edible whole grain is commonly called "brown rice."

White rice, which is also healthful, is brown rice that has been completely milled and "polished," removing the brown bran layer. Almost all U.S. white rice is then enriched with powdered nutrients, so it ends up with nearly the same nutrient content as brown rice, except for the fiber.

White rice, like all enriched grains, is also fortified with folic acid to help reduce birth defects. White or brown rice can be ground to make rice flour.

Rice's Starch and Protein Power

Starches, including rice starches, are long, complex chains of simple sugars, which is why they are often called "complex carbohydrates." Scientists at the FPSQ unit have been studying "resistant starch," a rice starch that is considered a form of dietary fiber. "By reaching the large intestine intact, resistant starches do not turn into sugar and cause no sugar rise," says Champagne.

The unit is also assessing "slowly digested starches," which are also "rice carbs," that lead to a more gradual rise in blood sugar levels than rapidly digestible starches. Whole-grain rice contains both resistant and slowly digestible starches.

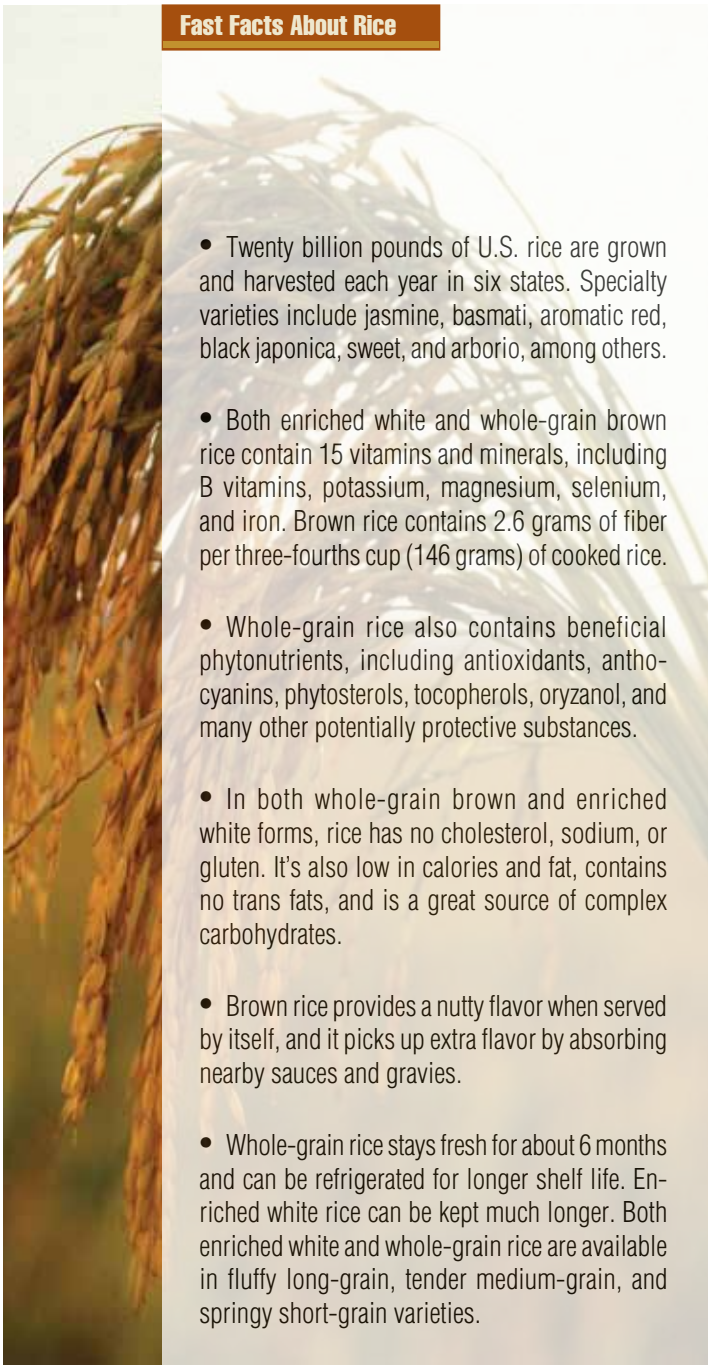
Champagne and Banville assembled several experts on these starches for the 2009 workshop, "Exploring the Health-Promoting Functions of Rice Starch and Protein," including ARS chemist Ming-Hsuan Chen with the ARS Rice Research Unit in Beaumont, Texas.

"Slowly digestible and resistant rice starches hold promise due to their ability to help satisfy hunger," says Champagne. "In the future, they may be developed into food ingredients and play a role in both delaying type II diabetes and providing other health benefits."

Cooking Rice on the Fast Track

Processed forms of rice, such as milled white rice and par-boiled or "converted" rice, take about 15 to 20 minutes to cook because their bran is not present. But whole-grain brown rice traditionally takes up to 50 minutes to cook. That's because the bran layers of brown rice are waxy and resist the water that is necessary for complete cooking and softening.

ARS food technologist Harmeet Guraya with the FPSQ unit developed a patented brown rice treatment that significantly reduces brown rice's long cooking time to 20 minutes—the cooking time of white rice. "Busy consumers may no longer be discouraged from eating whole-grain brown rice because of the long cooking time," he says.

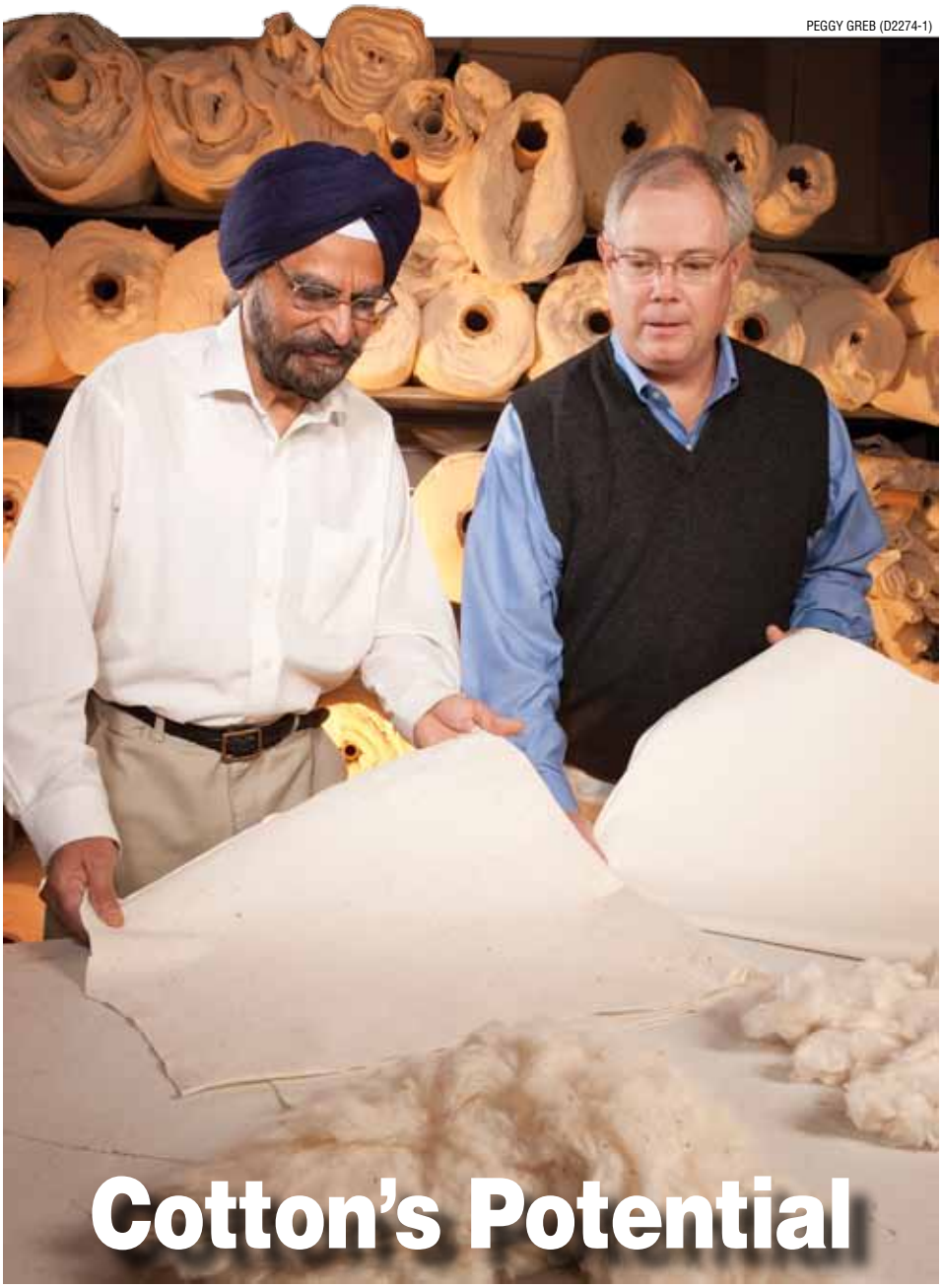


KEITH WELLER (K7577-1)

The patented technology—and consultation on how to deploy it properly—is available to qualified licensees. Those interested in licensing the technology can obtain information from the ARS Office of Technology Transfer, Beltsville, Maryland.—By **Rosalie Marion Bliss,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described at www.nps.ars.usda.gov.

Elaine T. Champagne is in the USDA-ARS Food Processing and Sensory Quality Research Unit, Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124; (504) 286-4448, elaine.champagne@ars.usda.gov. ✷



PEGGY GREB (D2274-1)

Cotton technologist Paul Sawhney (left) and research leader Brian Condon examine needled-punched nonwoven products made with classical raw (greige) cotton and precleaned raw cotton, respectively.

Cotton's Potential for Padding Nonwovens

About 98 percent of cotton produced worldwide today is used in woven and knitted fabrics and a variety of threads, ropes, and cables. These materials are known as "traditional textiles." A wide variety of machinery, chemicals, and manufacturing processes are involved in producing these textiles. For example, carding machines, which are outfitted with fine wires of different shapes, separate and coax cotton fibers into alignment. The aligned fibers then are formed into a long braidlike material called "sliver," which becomes the basic material for spinning yarns. These yarns are used mostly to weave or knit fabrics and to ply into sewing threads.

Innovations in textile technologies continue to automate and integrate manufacturing processes to increase fabric productivity and quality. During the last century, a new generation of textile equipment began making fabrics—known as "nonwovens"—in a continuous sheet form and at a very high production rate compared to that of woven fabrics.

New Uses for Cotton Fibers

Nonwoven fabrics, made from natural or synthetic fibers, are made *without* spinning or weaving yarns. Instead, these flat, porous sheets of fabric are mostly made by entangling or bonding the fibers. "The process of entangling fibers gives nonwoven fabrics strength," says Brian Condon, research leader with the Agricultural Research Service's Cotton Chemistry and Utilization Research Unit, in New Orleans, Louisiana. The unit is part of the ARS Southern Regional Research Center (SRRC).

At first, nonwoven fabrics were made using synthetic polymer-type fibers, such as polyester, polypropylene, and polyethylene, and some regenerated fibers, such as rayon, which is plant based. But in recent years, some nonwovens manufacturers have begun adding cotton to nonwovens used in absorbent hygiene products and personal-care wipes.

In 1968, a U.S. trade association was formed called "The Disposables Association." Recognizing that nonwoven fabrics were being used in an increasingly wider variety of end products, the organization changed its name in 1972 to the International Nonwovens and Disposables Association (INDA). The U.S. nonwoven fabrics industry now includes machinery producers, roll-goods producers, and raw-materials suppliers and converters. In 1976, INDA changed its name yet again to the Association of the Nonwoven Fabrics Industry, although the INDA acronym remains.

Ian Butler, INDA's director of market research, predicts rapid growth in some segments of nonwovens in both household and institutional markets. During the past few decades, the nonwovens markets in the United States, Europe, and Japan expanded greatly, mainly because of considerable advances in equipment, processing technologies, and product developments, according to Butler.

"The industry is now growing in most regions around the world. Total worldwide

growth of this industry is about 7 to 8 percent per year," says Butler. "The wipes industry segment in particular is undergoing tremendous growth."

From Hygiene to Auto Products

The disposable nonwovens markets include several different product categories, including absorbent hygiene products (baby diapers, feminine sanitary napkins, tampons, pantiliners, adult incontinence products, and underpads) and wipes for baby, personal, household, and medical care.

"We are astounded at the phenomenal growth of the general wipes industry, with some markets growing in the double-digit range per year," says Butler. "In the late 1990s, retail sales of all wipes in the United States and Canada combined was about $700 million; but within 5 years—by 2005—those sales jumped to $2 billion."

The nursing-facility industry, for example, is using adult diapers and bathing wipes made of nonwovens. At SRRC, projects are in the works to produce disposable bedsheets that would be particularly attractive to hospitals and nursing facilities.

Cotton, a premium fiber, enjoys the greatest market share of all natural fibers sold worldwide today, according to Janet O'Regan, director of strategic initiatives with Cary, North Carolina-based Cotton Incorporated.

While the use of cotton in nonwovens consists of less than 2 percent of all fibers currently used in nonwovens worldwide, some U.S. commercial products, like cosmetic pads and facial wipes, contain 100 percent cotton, according to experts.

"Since cotton is a significant crop internationally, we want to aggressively promote value-added utilization of cotton—particularly in the rapidly growing nonwovens industry," says Condon. "Cotton fibers can be added to nonwoven fabrics to produce products that are economical, functionally efficient, eco-friendly, and sustainable."

Materials engineer Dharnidhar Parikh, also at the ARS cotton utilization unit in New Orleans, reported that nonwovens made from blends of plant-based fibers—cotton, kenaf, jute, and flax—and polypropylene could be used in automobiles to insulate passengers from engine and outside noise. One study showed that each of the above-mentioned cellulose-based nonwovens had sound-absorbing properties comparable to those of the materials actually used in auto interiors.

Parikh also reported that the nonwovens made from blends containing biodegradable natural fibers could be made lighter in weight than their all-synthetic counterparts. "These blends have the potential to lower operating costs, because making lighter weight cars leads to better gas mileage," said Parikh. The 2007 study was published in *Textile Research Journal.*

Mattresses and other bedding products are required to be made with flame-retardant materials. One reason is that nonwoven materials are fluffy, so they burn more readily. It has been shown that suitable mattress and bedding nonwoven materials can be made from raw, virgin lint, which is ginned cotton that has not been bleached. Virgin cotton is referred to by industry as "greige" (pronounced "gray") cotton.

"Virgin cotton is much less expensive than bleached cotton or some synthetics," says Condon. ARS studies are now under way to determine the flame-retardant properties of such materials and to improve those properties. "We are working on several specific approaches to improving flame-retardant performance, and so far, we've seen several good successes in the lab," he says.

Triumph Over Adversity

Use of cotton fibers in the nonwovens sector has been limited partly by the production costs of bleaching cotton. "We wanted to explore new research avenues to increase the use of cotton in nonwovens," says Condon.

Then, a crisis occurred that accelerated change.

In 2005, Hurricane Katrina shut down the SRRC. "We used that disaster as a turning point to change direction and emphasize use of cotton in nonwovens as our new area of cotton research," said Condon. "We purchased a new fleet of state-of-the-art nonwoven machinery and equipment for conducting basic and applied research to develop new technologies to incorporate cotton into existing and new products." In 2007, SRRC opened its Cotton Nonwovens Research Laboratory and Pilot Facility.

The machinery includes three lines of nonwovens research equipment totaling 16 machines. The needle-punch line is made by TechnoPlants; the hydroentanglement line is made by Fleissner; and the finishing line is made by Mathis.

Hydroentanglement, sometimes called "spunlacing," is a process in which closely

PEGGY GREB (D2275-1)

Technician Pablo Ali Salami (left), research leader Brian Condon (middle), and technician Lucien Duplessis apply a new treatment to a hydroentangled greige cotton nonwoven fabric on the Mathis laboratory equipment. This device is part of a fleet of state-of-the-art equipment for the Cotton Nonwovens Research Laboratory and Pilot Facility at the Southern Regional Research Center in New Orleans.

PEGGY GREB (D2276-1)

Cotton technologist Paul Sawhney (left) and textile technologist Michael Reynolds prepare an experimental trial for producing a hydroentangled cotton nonwoven fabric on a commercial-grade hydroentanglement system.

spaced, high-pressure water jets strike a web or batt of loosely held fibers supported on a screenlike moving belt made of polyester woven fabric. The jet-impacted fibers are then rearranged and entangled to form a strong sheet of woven-like fabric. This hydroentangling technique is a leading technology, especially within the cotton and staple-fiber nonwovens sector, and is sometimes combined with needle-punching.

Several test instruments were purchased to assess the products of the research efforts. Condon also had existing cotton carding equipment modified to produce a web of cotton fibers instead of sliver. The result of this lab-equipment revolution is the ARS-SRRC Cotton Nonwovens Research Center. The expanded research effort now involves efficient use of the new fleet of sophisticated equipment, more emphasis on processing nonwoven fabrics, and more outreach to a variety of potential markets.

Nonbleached Cotton's Debut

"Most of the cotton fiber used in the nonwovens sector up until now has been bleached cotton," says Butler. "But bleached cotton is relatively expensive and complex to process, so there is considerable effort to develop a wipe using nonbleached cotton."

ARS cotton technologist Paul Sawhney, the lead scientist of the cotton-based nonwovens research program at the center, and colleagues conducted preliminary studies to investigate the use of virgin cotton in nonwovens. The studies showed that ginned virgin cotton could be processed directly on existing cotton carding equipment. "Cotton's natural waxes actually provide a measure of lubrication that considerably helps in carding the fibers," says Condon. "Bleached cotton fibers create tough problems in the carding process."

"We then efficiently processed the virgin cotton on the center's modern nonwoven fabrics production equipment," says Sawhney. "We were pleased with the quality of the first experimental 100-percent virgin cotton nonwoven fabrics that we produced." Sawhney reported some of those findings in the proceedings of the 2009 International Cotton Conference, held in Bremen, Germany.

"We have produced several lightly preneedled condensed webs of virgin cotton on commercial-grade needle-punch equipment to investigate the

Technician Adrian Mejia (left) and textile chemist Chuck Allen (center) examine a cross-lapped web (batt) as they prepare to feed it into the needle-punch machine to produce a fabric containing mostly cotton. Technician Farrell Screen waits for the fabric on the exit side.

PEGGY GREB (D2279-1)

Needle-punch equipment is used to entangle fibers to produce a delicate, lightweight nonwoven material from greige cotton. This material may be used in industrial wipes.

PEGGY GREB (D2280-1)

hydroentanglement process of fabricating nonwovens," says Sawhney. "We have evaluated the processing of virgin cotton on a TechnoPlants needle-punch machine and on a Fleissner hydroentanglement system and the properties and characteristics of the nonwoven fabrics produced." The team found that greige cotton, which is naturally water repellent, can be made absorbent mainly by controlling the hydroentanglement water pressure.

Various forms of cotton include by-products, such as discounted cottons, ginning waste (motes and linters), and textile processing wastes (card strips, comber noils). Sawhney believes that these forms of cotton could be suitable for use in nonwovens such as wipes, upholstery, and quilt-blanket inserts.

The researchers published these findings in a 2010 study, "Advent of Greige Cotton Nonwovens Made Using a Hydro-Entanglement Process" in *Textile Research Journal*.

No Bleach, No Debris

About 25 years ago, Tom Gary, owner of Greenwood, Mississippi-based Wildwood Gin, Inc., began specializing in cleaning gin waste, or linter, and providing that fiber to paper mills and traditional textile mills. But in the last decade, Gary's team, which includes son Lawson Gary, began purchasing and drastically modifying textile equipment to create an entirely new plant and textile process.

"The new process removes trash from regular cotton fibers at unprecedented levels," says Lawson Gary. Trash includes leaves, sticks, burs, bark, and other debris in ginned cotton.

"In the past 2 years, we have been working with scientists at the SRRC Cotton Nonwovens Research Center to produce and evaluate fabrics made with our ready-to-use, clean, natural-cotton fibers," says Gary. "We provide high-quality reprocessed cotton fibers that are cleaned with no chemical bleaching, water, or process heat." According to Gary, these fibers have been very well received by hydroentanglement and needle-punch nonwovens manufacturers in the United States and western Europe.

"Working with the SRRC scientists has allowed us to test our fibers' performance in a number of 100-percent cotton nonwoven materials," says Gary. The result is that Wildwood Gin has begun marketing mechanically cleaned, natural cotton to manufacturers of personal care products within the nonwovens industry.

"Elimination of the scouring process in cotton-based nonwovens is a major milestone in the value-added utilization of greige cotton in nonwovens." —Paul Sawhney

"An international brand is making plans to roll out a number of personal-care nonwoven products that include our fibers," says Gary. "The SRRC researchers have made first-of-a-kind samples and modeled production runs of 100-percent cotton nonwoven fabrics in their pilot facility. Those cotton-containing test fabrics helped us with proof-of-concept and enabled real-time use of these fibers in personal-care products."

"The ability to put precleaned, nonbleached greige cotton directly into nonwoven fabrics could be considered an industry breakthrough," says O'Regan.

In a new study, SRRC scientists have compared two forms of cotton: One was ginned and conventionally cleaned, and the other was cleaned with Wildwood Gin's new mechanical-cleaning process.

The study showed that nonwoven textile plants, with certain nominal modifications, could use the mechanically cleaned, natural cotton without adding new equipment. This comparison study was published in 2011 in *Textile Research Journal*.

According to Sawhney, mechanically precleaned, nonbleached greige cotton is a good candidate for use in newer and improved nonwoven materials and end-use products, such as disposable, reusable, recyclable, washable, and perhaps even flushable wipes. Other products could be institutional uniforms, toweling, sheeting, furnishings, tablecloths and mats, napkins, undergarments, pajamas, and even sustainable "green" denims.

"Elimination of the scouring process in cotton-based nonwovens is a major milestone in the value-added utilization of greige cotton in nonwovens," says Sawhney.

"The SRRC researchers are helping industry understand how to process virgin cotton and use it directly in nonwoven fabrics without bleaching," said O'Regan.

New Nonwoven Products

SRRC's textile technologist Michael Reynolds says that in 2010, several nonwovens roll-goods manufacturers and retailers expressed interest in the development of cotton-containing nonwoven products, especially wipes.

"We have a trust agreement with one group to develop cotton-based nonwoven products for the home sewing, crafting, and quilting markets," said Reynolds. "Another group gave us specifications to develop a very-heavy-weight, needle-punched, 100-percent cotton nonwoven material." SRRC provided a piece of the required material, and the cooperator is evaluating the sample for potential commercial application.

"We anticipate that cotton can be useful in many other end-use applications of existing nonwoven products," says Reynolds.—By **Rosalie Marion Bliss,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described at www.nps.ars.usda.gov.

Brian Condon is at the USDA-ARS Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124; (504) 286-4540, brian.condon@ars.usda.gov.

Technician Pablo Ali Salami (left) and textile chemist Chuck Allen discuss new uses for the colorful cotton-based nonwoven fabrics they dyed and finished in the wet-finishing laboratory.

PEGGY GREB (D2277-1)

Solving Challenges in Sugarcane Factories and Refineries

Award-Winning Factory and Pilot Plant Studies Provide Solutions

PEGGY GREB (D2197-1)

In the new sugar-processing pilot plant at SRRC, chemist Gillian Eggleston (center) works with chemical engineer Brett Andrzejewski (right) and physical science technician Eldwin St. Cyr (left) to process sugarcane.

Very high purity. Very low color.

These terms aren't describing the latest diamonds from Tiffany's. They describe the ideal qualities of sugar crystals after industrial processing.

In the field, the cane is collected by combine harvesters that chop up, or "billet," the cane into pieces of about 9 inches in length. Those pieces are shredded at the factory. Juice is then extracted and must be clarified, evaporated, crystallized, and centrifuged, resulting in brownish-yellow crystals called "raw sugar" and molasses. That nonfood-grade raw sugar is then sent to a refinery where it is further melted, clarified, and crystallized into the white sugar found in supermarkets.

The nemesis of these sugar crystals is "trash"—impurities such as leaves and tops and muddy soil that piggyback on sugarcane from the field into the factory. These impurities make processing and clarifying cane juice more difficult.

At the ARS Southern Regional Research Center (SRRC) in New Orleans, Louisiana, chemist Gillian Eggleston has been studying sugarcane that comes into factories containing too much trash. When "trashy" cane enters a factory, processing problems occur that can hurt the bottom line. Eggleston is in the SRRC Commodity Utilization Research Unit.

Traditionally, trash amount has been controlled by burning some sugarcane in the field. But environmental concerns have led to a shift away from burning cane in open fields, and that means more trash on the green cane coming into the factory.

Eggleston has now shed light on the effect of processing green, versus burnt, cane. She traveled to South Africa for 3 months in 2008 and there conducted two large factory and pilot plant studies.

In her studies, she processed burnt whole-stalk cane and burnt and unburnt (trashy) billeted cane to assess the quantity and quality of sugar produced from each of these materials—and the effect of trash on the process.

"We separated the brown and green leaves, growing-point region, or top stalk, and the rest of the stalk and weighed each of these tissues just before they went into the factory," says Eggleston. "And then we could correlate that data with the results we got."

(D2200-1)

During a large sugarcane factory trash study in 2008, Gillian Eggleston (left) collects green sugarcane billets from a storage pile at the Noodsberg sugarcane factory in the KwaZulu-Natal Midlands area of South Africa.

Her study showed dramatic effects of harvesting green and burnt billets of cane compared to burnt, whole-stalk cane. "Based on samples produced across the pilot plant that simulated all factory processes, green cane detrimentally affected purity, sugars, ash, and color as well as physical properties such as clarification performance," says Eggleston. "The data showed us, for the first time, that undesirable color in factory sugar is actually coming from the green leaves in the growing-point region, which occurs at the top part of the stalk."

PEGGY GREB (D2199-1)

Eldwin St. Cyr inspects the growth of sucrose crystals manufactured in a vacuum pan at SRRC's sugar-processing pilot plant.

New Approach to Lowering Color

Traditionally, several processes have been used in factories or refineries to lower or remove color—but they are all expensive. Eggleston estimates, from her studies, that for every 1-percent increase in trash levels, there is an increase of about 50 international color units (ICU) for raw sugar and 25 ICU for refinery sugar. She also found that for every 1-percent increase in trash, there is about a one-fifth-percent drop in recoverable crystals. That translates into a $96 million loss per year to the U.S. sugarcane industry.

Her work has led to a recommendation to U.S. sugarcane growers and processors that even a small reduction—such as less than 10 percent—in total trash levels processed at the factory could be more efficient and cost-effective than other factory color-removal processes.

Eggleston won the George and Eleanor Meade Best Paper Award from Sugar Industry Technologists, Inc., (SIT) for her 2009 paper "Factory Trials To Determine How Trash Impacts Downstream Processing," presented at its annual international meeting. This work was also published in the *Proceedings of the South African Sugar Technologists' Association* and won the association's 2009 Talbot-Crosbie award for impact on the industry and relevance of the research.

After returning from South Africa, Eggleston spent 2 years building a sugar-processing pilot plant at SRRC. There, a multitude of further experiments can be conducted to study U.S. sugarcane varieties.

Controlling Starch, Controlling Amylase

Another problem associated with the increase in processing green, unburnt cane is increased starch levels in processed raw sugars and products made with those sugars. Use of new U.S. sugarcane varieties is also associated with increases in starch. Now, Eggleston has looked closely at the causes of excess starch in raw and refined sugars, molasses, and food products.

In the United States, an enzyme called "amylase" is added during sugar factory processing to break down long chains of unwanted starch. Eggleston's research alerted factory processors and refiners to the problem of unwanted carryover amylase activity in molasses and raw sugar if high-temperature commercial amylases were applied in the factory.

"Unless the process of applying factory amylase was improved, starch content in raw sugar would continue to rise," says Eggleston.

Trials were conducted in three Louisiana-based factories using an amylase that was intermediate-temperature (IT) stable. Eggleston used diluted solutions of amylase to improve contact between the amylase and starch. "When added to factory tanks, the solutions break starch down into smaller, more manageable molecules," she says.

One of the solutions she tested contained IT-stable amylase diluted threefold in water at the factory. When this solution was added at a dose of 2 parts per million (ppm) per ton of cane juice, starch breakdown was about 32 percent. When the dose was raised to 5 ppm per ton of cane juice, starch breakdown increased to 42 percent. Adding the amylase to the next-to-the-last evaporator—instead of the last evaporator as is traditional—improved starch breakdown even more. Another plus: Using diluted solutions is more cost-effective than using undiluted amylase.

Eggleston won SIT's Frank Chapman Memorial Award for Best Poster Presentation for her work on optimizing amylase applications in raw sugar manufacture that directly concern refiners. A two-part 2008 paper on the work appears in the *International Sugar Journal*. Her recommendation that starch buildup can be better controlled or prevented by applying IT-stable amylase is now being followed by several factories in Louisiana.—By **Rosalie Marion Bliss,** ARS.

This research supports the USDA priority of promoting international food security and is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described at www.nps.ars.usda.gov.

Gillian Eggleston is in the USDA-ARS Commodity Utilization Research Unit, Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70179-0687; (504) 286-4446, gillian.eggleston@ars.usda.gov.


DANIEL WREN (D1757-1)

How To Make a Wave Behave

In the lower Mississippi Delta, farmers often build ponds for aquaculture and for storing surface water to irrigate crops. But erosion generated by wind-driven waves can reduce reservoir levee widths by a foot every year, and repairs can be needed as soon as 5 years after a reservoir is completed.

It's not simple—or cheap—to patch up a reservoir with silt loam levees that can stretch over a mile and that are 25 to 30 feet wide. The costs can average $3 per foot, which adds up to around $15,000 per structure.

People have tried to stabilize the levees with tires, construction materials, or vegetation, but hydraulic engineer Daniel Wren is experimenting with another approach. "We wanted to see if we could find a way to cut down on the erosive energy hitting the levees," he says.

Wren, who works at the Agricultural Research Service's Watershed Physical Processes Research Unit in Oxford, Mississippi, partnered with ARS hydraulic engineer Carlos Alonso (now retired) and University of Mississippi research associate Yavuz Ozeren for his research. The team gathered data about wind and wave dynamics from a 70-acre irrigation reservoir in Arkansas. Then they took their data into the lab and designed several wave barriers that they tested in a 63-foot-long wave flume.

Lab results indicated that a floating barrier held in place by two rows of pilings would provide the most effective embankment protection from wave action (see diagram).

The barrier was made of a 9½-inch-diameter tube that was attached to a 4¾-inch-diameter tube with a 24-inch length of smaller tubing. Since it was confined between the two rows of pilings, the barrier was able to rise and fall with fluctuating water levels—unlike a barrier tethered to the bottom of the pond, which might end up below the water surface as reservoir levels rise.

The team found that this two-tube barrier was able to dissipate 75 percent of wave energy for waves within the design range before they washed against the levees. The waves lost some of their force when they broke against the first tube and then lost even more energy as they broke against the second tube.

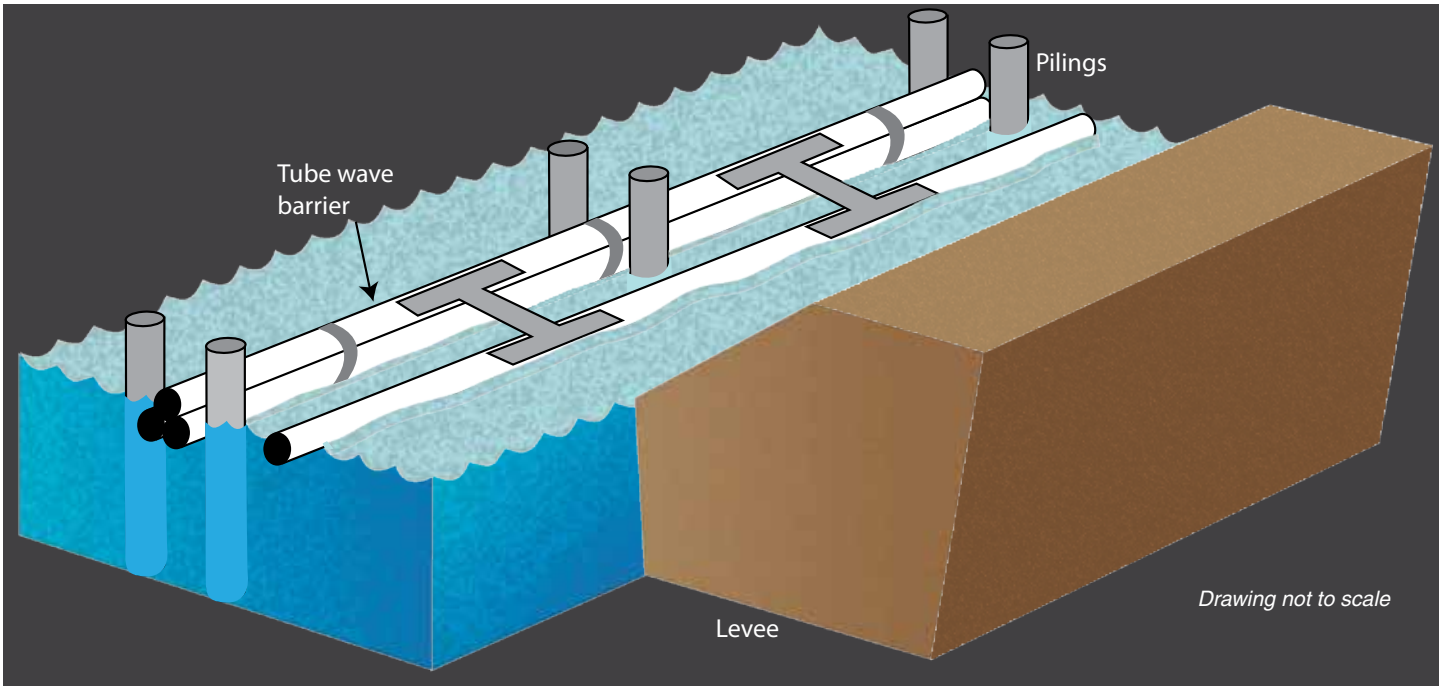
Wren's team calculated the costs of using different materials for constructing the wave barriers, including the logistics of transporting materials to the site and the labor involved in assembling and installing the barriers. A key to the barrier's effectiveness was its total combined diameter. The engineers found that bundling several lengths of smaller tubing together to obtain an optimal diameter worked as well as one tube with a larger diameter. And transportation costs were lower for the smaller tubing.

"The cost savings could be significant when you need to protect several hundred yards of levees," Wren observes.—By **Ann Perry,** ARS.

This research is part of Water Availability and Watershed Management, an ARS national program (#211) described at www.nps.ars.usda.gov.

Daniel G. Wren is with the Watershed Physical Processes Research Unit, USDA-ARS National Sedimentation Laboratory, 598 McElroy Dr., Oxford, MS 38655; (662) 232-2926, daniel.wren@ars.usda.gov.

C. BEUCHERT-ARS



STEPHEN AUSMUS (K10519-6)

Blowing in the Wind

An ambient PM10 high-volume sampler in a west Texas dust storm. A storm like this exposes samplers to dust particles greater than 10 micrometers, and larger dust particles increase the overall error associated with ambient air samples.

STEPHEN AUSMUS (K10513-9)

Unless, perhaps, someone in our family has a dust allergy, most of us probably don't think much about dust. And if we do, we probably think about the dust on our coffee tables.

Dust, however, isn't just in our houses. It's everywhere and can affect our health. And all dust is not created equal: The smaller particles, which are more difficult to see, are potentially the most dangerous.

In 2006, the U.S. Environmental Protection Agency (EPA) lowered the limit on average PM2.5 emissions over a 24-hour period from 65 to 35 micrograms per cubic meter. Some states have set the standard much lower. This comes from a growing concern that the smallest dust particles pose the biggest health threat, because they are small enough to penetrate deeply into peoples' lungs.

Agricultural engineers Greg Holt (left) and former ARS scientist Michael Buser, now with Oklahoma State University, Stillwater, change filters from particulate-matter samplers and collect meteorology data while sampling dust generated by a rolling cultivator (background).

"PM2.5" refers to particulate matter less than 2.5 microns in diameter—2.5 microns is about 1/30th the thickness of a human hair.

As states implement required plans to achieve federal standards—or even stricter ones—and begin to regulate various types of industries, they face the problem of a scarcity or, in some cases, a lack of data on how much PM2.5 those industries currently emit.

In the case of agricultural operations, EPA and the Agricultural Research Service are working together with the industries and the states to develop better

Sound Science Sound Air

MIKE BUSER (D2219-1)

DEREK WHITELOCK (D2218-1)

Standing in a manlift basket about 30 feet off the ground, agricultural engineer Clif Boykin inserts a sampling probe into a cyclone stack at a cotton gin in California.

To accurately determine the total PM10 and PM2.5 emissions from a cotton gin in west Texas, ARS biological science aids Arnold Gomez and Bud Welch directly sample exhaust from the gin's many cyclones. Samples are then brought back for processing in the ARS Air Quality Laboratory in Lubbock.

science-based information and methods to set standards.

Cotton Belt Seeks "Just the Facts" on Air Pollution

Roger Isom, executive vice president of the California Cotton Ginners and Growers Association in Fresno, says that California, Arizona, and North Carolina are among the first states to begin evaluating PM2.5 emissions from agricultural and other types of industries.

Cotton gins are one of the many agricultural operations these states are looking at. As they do with other industries, the states have to decide whether to require much more expensive PM emission controls, which could risk a business's survival. In California, the gins are already required to install enhanced cyclone pollution-control devices at all emission points. These cyclones capture cotton lint, stems and other plant parts, and soil and spin them so most of the material collects at the bottom and clean air comes out the top.

One of the options California's San Joaquin Valley Air Pollution Control District is considering—if cotton gins are designated as "significant sources of PM2.5"—is to require "baghouses" in addition to cyclones. Baghouses are facilities that house multiple air-filter bags. These are used in other industries, including foundry and steel operations and chemical manufacturing. The bags look like large tube socks that are generally 6 to 10 inches in diameter and often are 10 to 20 feet long.

$1 Million-Plus Controls May be Too Much for Cotton Gins

Agricultural engineer Mike Buser, formerly with ARS and now at Oklahoma State University at Stillwater, says that "one of the California gins we tested has 13 separate air-quality emission systems. That gin would have to have two baghouses, each holding about 500 bags. That would cost more than $1 million."

Isom shares the concerns of gin associations throughout the cotton belt—which stretches from California to North Carolina—that the lack of data could lead to an erroneous overestimation of PM2.5 emissions. So they pressed for research to find out how much gins actually emit.

Cotton gins in states like Missouri are already finding it difficult to obtain air-quality permits to operate, because the standards are based on EPA models that are more suited to industrial smokestacks. Gins' exhaust pipes are much closer to ground level, mostly 30 feet high, with the tallest ones usually no more than 65

Sound Science Sound Air

DEREK WHITELOCK (D2221-1)

ARS scientists measure the levels of PM2.5 and PM10 in the air outside a cotton gin by surrounding the gin with 126 ambient air samplers, such as this one located in a cotton field near a cotton gin in west Texas.

feet high, so their emissions tend not to travel far from the gin. These models may overestimate the distance gin dust travels by 10 times.

Urban Samplers, Models Wrong for Cotton Gins?

Buser found that EPA samplers could be overestimating PM2.5 emission concentrations by 14 times. Buser was at the ARS Cotton Production and Processing Research Unit in Lubbock before transferring to Oklahoma State University in 2009. He continues his research as an integral part of the "Characterization of Cotton Gin Particulate Matter Emissions Project."

Isom, well aware of Buser's research, called Buser in 2007 and asked for help in getting scientific answers on PM2.5 concentrations.

So, in 2008, ARS scientists at cotton ginning labs—including Buser; Derek Whitelock, an agricultural engineer with the ARS Southwestern Cotton Ginning Research Laboratory in Mesilla Park, New Mexico; and fellow agricultural engineer Clif Boykin, at the ARS Cotton Ginning Research Unit in Stoneville, Mississippi— organized a major 4-year project to intensively sample emissions from seven cotton gins strategically located throughout the Cotton Belt. From the very start, they planned the project with federal and state regulators and the cotton industry to address the various concerns of each cotton-growing region.

"Texas, for example, wanted more information on the total amount, size, and percentages of all the particles emitted from gins, including PM10. The cotton growers' and ginners' organizations wanted more accurate computer models to predict emissions," Buser says.

To accurately determine the total emissions—PM10 and PM2.5—from a cotton gin, they directly sample the exhaust from the gin's many cyclones, using EPA methods. To do this, the scientists joined forces with a certified stack tester from California to measure the PM emissions from cotton gins.

They also measure the level of PM2.5 and PM10 in the air outside a cotton gin by surrounding each gin with 126 ambient air samplers, compared to the half-dozen samplers used in previous, less intensive, studies. There are 6 sampling points at different levels on each of 12 towers. Each tower is 33 feet tall.

Whitelock says, "More than 1,500 samples are brought back from each gin for processing," which is done in the ARS Air Quality Laboratory at Lubbock, under the direction of research leader Greg Holt.

Intensive Air Sampling

They have already sampled one gin in New Mexico, two in Texas, two in California, and one in Missouri. In 2011, they'll test the last gin, in North Carolina.

It will take another year, through 2012, to analyze the data from all the tests.

At a field day event in Pullman, Washington, soil scientist Ann Kennedy uses canning jars to illustrate the greater volume of larger sized clumps of soil found in direct-seed soil compared to soil tilled multiple times. These larger sized clumps will not be subject to wind erosion.

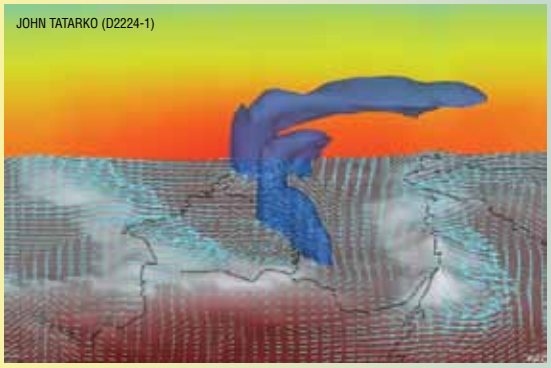
DENNIS BROWN (D2227-1)

Predicting Pathways for Windblown Dust

An Agricultural Research Service scientist and partners have combined models of wind erosion and regional climate patterns to simulate the sources and dispersion of particulate matter—such as tiny bits of soil and other substances—blowing in dust storms around Mexico City.

People who inhale particulates with a diameter of 10 micrometers or less (PM10) can develop respiratory problems, so public health officials are anxious to predict how these airborne pollutants are dispersed over time.

Soil scientist John Tatarko, who works at the ARS Engineering and Wind Erosion Research Unit in Manhattan, Kansas, collaborated with scientists at the National Autonomous University of Mexico on this research. His partners included Emmanuel Díaz, Arón Jazcilevich, Agustín García, Ernesto Caetano, and L. Gerardo Ruíz-Suárez.



This three-dimensional simulation of an actual dust plume (shown in dark blue) over the Valley of Mexico was generated by the combined model system called "MCCM-WEPS."

The team combined two existing models to explore how wind erodes PM10 from farm fields and dry lakebeds around Mexico City, where poor air quality is an ongoing concern. The first model was the Wind Erosion Prediction System (WEPS), which was developed by ARS scientists to simulate rates of soil loss, PM10 emissions, and other data for specific erosion events.

The other model, developed at the Karlsruhe Institute of Technology in Germany, was the Multiscale Climate and Chemistry Model (MCCM). It combines information about weather conditions and other factors to produce estimates of the transport of air pollutants. The combined model system was called "MCCM-WEPS."

The researchers collected field data on four dust storms around Mexico City during the dry season. Then they compared PM10 erosion rates from these storms with MCCM-WEPS simulations of erosion rates for the same storms.

The team found that the simulated rates produced by MCCM-WEPS generally aligned with the PM10 erosion rates that had been measured from the dust storms—and accurately simulated the PM10 dispersion downwind. The model also suggested that the horizontal transport of PM10 accelerates when wind currents mix and form low-pressure systems, which prompt the upward movement of the particulates. These combined findings all indicate that wind erosion is a major cause of high PM10 concentrations in Mexico City.

Results from this research were published in 2010 in *Aeolian Research*.—**Ann Perry,** ARS

California officials and gin associations are especially anxious for the project data on their two gins, giving them the first real numbers to work with.

Whitelock says that he, Buser, and Boykin "set up a gin advisory group and an air-quality advisory group to help us plan the project, and we always invite cotton gin associations and regulators to observe each sampling campaign."

The gin advisory group includes people from cotton gin associations; Cotton Incorporated, whose world headquarters are in Cary, North Carolina; the National Cotton Council of America in Cordova, Tennessee; and Texas A&M University at College Station. It was formed to identify prospective gins for sampling and to act as liaison between the gins and ARS.

The air-quality advisory group includes people on the gin advisory group as well as from EPA and state environmental regulatory agencies and the U.S. Department of Agriculture. This group was formed to advise on methods and equipment for sampling, quality control, and data analysis.

"Participation of these advisory groups is essential to the success of this project and for the results to be accepted by industry and regulators," Whitelock says. "This way we have their buy-in on our data-collection methods before we ever start, minimizing the chances of having our results questioned after the experiments are over," Whitelock says.

Funding for the project comes from several sources, with a long list of cooperators.

"With cotton-production costs soaring, all decisions on more costs have to be based on sound science. That is key to ensuring that the U.S. cotton industry remains strong and competitive globally," Whitelock says.

Pacific Northwest Farmers Can See Soil Blow Away

EPA's regulations on PM2.5 and PM10 affect every aspect of agriculture, not only cotton gins but also cattle feedlots and farming operations.

For the Columbia Plateau region of the Pacific Northwest, the focus is on topsoil blowing in the wind: The smaller particles occasionally contribute to poor air quality in the region.

Farmers in this wind-erosion-prone region are as anxious as any others about the prospect of farms being regulated like cotton gins and other industries, with fears of urban air-pollution samplers surrounding their farmland. But they also want their rich topsoil to stay in place, so they are eager to reduce wind erosion.

Brenton Sharratt and Ann Kennedy, at the ARS Land Management and Water Conservation Research Unit in Pullman, Washington, are identifying practices that will keep the soil from blowing away.

Sharratt, research leader of the unit, examines the physical properties, and Kennedy, a soil scientist, studies the biological properties of soils that affect wind erosion.

Sharratt measures the quantity and size of soil particles blown off fields while Kennedy analyses the soil for its lipid content from the microbes living in the soil. Each microbe community has a unique fingerprint that can be used to identify the soil. Sediment deposited far downwind of a field can potentially be traced back to where it blew from.

Although she and Sharratt focus on soils of the Columbia Plateau region in parts of Idaho, Oregon, and Washington State, Kennedy also works with ARS scientists in Colorado, Idaho, Missouri, and Texas on fingerprinting soils. The scientists exchange soil samples to study a variety of soils from different regions. Interestingly, microbial communities from dirt and gravel roads differed from adjacent agricultural soils whether in Washington or Texas.

"Apparently, the microbial communities found on roads change with time because of the lack of plants and restricted water infiltration," Kennedy says.

They collect samples from devices that trap blowing soil particles; these devices were invented by ARS scientists in Lubbock.

Sharratt is investigating how soil and crop management affects the amount of soil and PM10 eroded from fields during high winds. Tillage and crops can influence soil roughness, soil aggregation (or size of soil clods), and the quantity of crop residue on the soil surface. All these factors affect the soil's susceptibility to erosion by wind or water. He is also looking at how soil moisture and crusting can protect the soil from wind erosion.

"Maintaining roughness and nonerodible material such as crop residue on the soil surface is key to controlling wind erosion" Sharratt says. "We're looking for ways to manage soils that minimize blowing and are cost effective for the farmer."

Ultimately, Sharratt, Kennedy, and their colleagues are looking for management practices that reduce the soil's vulnerability to wind erosion. They know that no-till—eliminating plowing or frequent tillage before planting, leaving adequate amounts of protective residue from previous crops on the surface—is very effective at reducing wind erosion and PM10 emissions from agricultural lands. But no-till is often not economically viable in the very driest parts of the Columbia Plateau. There are challenges yet to be worked out before no-till systems can be used with success throughout the region.

One tillage technique that seems promising is undercutting, which slices beneath the soil surface and gently lifts and sets down the uppermost layer of soil in place. Undercutting severs the roots of weeds without inverting the soil as a plow does.

"Undercutting has reduced soil and PM10 loss from fields during high wind events by as much as 65 percent as compared to conventional tillage practices in the drier parts of the region," Sharratt says. "This breaks open compacted layers and breaks up harmful fungi, while leaving the soil and organic matter intact, with positive effects on beneficial microbes," Kennedy says.

"We always thought that most of the carbon that makes up organic matter was lost to the atmosphere as carbon dioxide," Kennedy says. "But we have found that a lot of organic matter is actually being lost to the wind as soil blows off a farm field, as much as 10 percent of total organic matter losses. This is one more incentive, as though any were needed, for farmers to keep the soil in place. "—By **Don Comis,** ARS.

This research supports the USDA priority of responding to climate change and is part of Climate Change, Soils, and Emissions (#212), an ARS national program described at www.nps.ars.usda.gov.

To reach scientists mentioned in this story, contact Don Comis, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1625, donald.comis@ars.usda.gov. ✻

Sound Science Sound Air

BRENTON SHARRATT (D2215-1)

One can see the dramatic amount of soil loss; over 3 inches of the potato stem including roots were exposed after a 2010 dust storm in southeastern Washington State.

CONSUELO ESTEVEZ DE JENSEN (D2296-1)

ARS and CGIAR

Working To Provide International Food Security

At the Instituto de Investigacão Agronómica in Angola, Africa, ARS geneticist Timothy Porch (center) shows a group of technical staff and students how to hybridize common bean for improvement of resistance to common bacterial blight and angular leaf spot.

There is an old saying that it takes a village to raise a child. Well, it takes a planet to feed all of them. While each continent, country, and region faces unique agricultural challenges, it will take a committed global focus to meet those challenges. The Agricultural Research Service (ARS) and the Consultative Group on International Agricultural Research (CGIAR) collaborate again and again to do just that. CGIAR is a network of 15 international agricultural research centers, several of which are featured below.

Solutions for Serious Animal Diseases

Rift Valley fever, foot-and-mouth disease, and East Coast fever are some of the diseases that harm livestock and threaten the livelihood of farmers in developing nations like those of sub-Saharan Africa. The challenge of keeping these animals alive, healthy, and productive is one that's being addressed through worldwide partnerships. Scientists at ARS and CGIAR's International Livestock Research Institute (ILRI) in Nairobi, Kenya, are working together to help producers increase and sustain their livestock and farm productivity.

Laying the groundwork for an East Coast fever vaccine

Developing a vaccine that protects cattle against East Coast fever (ECF), a devastating disease in eastern and central Africa, is a team effort for scientists at ILRI and ARS's Animal Disease Research Unit (ADRU) in Pullman, Washington.

Researchers are in their fifth year of a collaborative project, "Combination Vaccines for Tick-Borne Diseases," which involves studying the tick, *Rhipicephalus appendiculatus,* that transmits *Theileria parva,* the parasite responsible for ECF.

"The focus of our work in the United States is Texas cattle fever, and in Kenya the focus is East Coast fever," says ARS entomologist Glen Scoles. "Because these parasites and the ticks that transmit them are so similar, proteins we identify in one system can also be studied in the other."

A vaccine for ECF could lead to a vaccine for Texas cattle fever, he says.

"It is important that the global community works together to control diseases that limit food and fiber production, and East Coast fever is one of those diseases," says ADRU's research leader Don Knowles. "Although we currently control most such diseases in the United States, what we learn from this collaboration will help prevent parasitic diseases here as well as in other countries."

Scoles, Knowles, and Massaro Ueti, an ADRU veterinary medical officer, teamed up with ILRI scientists to develop a polymerase chain reaction test that detects parasite DNA in ticks to quantify the level of infection. Two strains of nymphal ticks, developed at ILRI to have different *Theileria parva* susceptibilities, were allowed to feed simultaneously on infected calves and compared. The Muguga strain had a low level of parasitic infection, and the Kiambu strain was highly susceptible.

The next step will be to uncover the genetic basis for the difference between the strains and identify tick proteins that are produced in response to infection. These might be good targets for a vaccine that would help control both the parasite and the ticks that transmit them.

"A similar approach can be applied to the tick that transmits Texas cattle fever," Scoles says.

Preparing for Rift Valley fever vaccine trials

Scientists at the ARS Center for Grain and Animal Health Research (CGAHR) in Manhattan, Kansas, and international institutions in sub-Saharan Africa are developing and evaluating control strategies for diseases like Rift Valley fever (RVF), which is transmitted by mosquitoes to animals and humans.

A viral disease mainly in ruminant animals, RVF causes abortions in livestock, high mortality in young animals, and can be lethal in humans. Symptoms include fever, jaundice, and diarrhea.

CGAHR scientists at the Arthropod-Borne Animal Disease Research Unit and colleagues at Kenya Medical Research Institute (KEMRI) and Kenya Agriculture Research Institute (KARI) are teaming up with scientists at ILRI to help determine how to control RVF. At KEMRI, mosquito populations are being studied for potential RVF activity between outbreaks. At KARI, researchers are building infrastructure and developing tools to conduct large RVF vaccine trials and diagnostic evaluations.

"The next stage is to actually conduct vaccine studies using ILRI researchers' expertise in immunology," says CGAHR microbiologist William Wilson.

Testing new methods to track FMDV

A novel tool that tracks the adaptive immune response to vaccines for foot-and-mouth disease virus (FMDV) is being applied to cattle at ARS's Foreign Animal Disease Research Unit at Plum Island Animal Disease Center in Orient Point, New York, and at ILRI.

Foot-and-mouth disease is an acute, highly contagious infection that threatens the health and economic value of livestock worldwide. Though the disease hasn't been seen in the United States since the 1920s, recent outbreaks have been reported in Japan, Bulgaria, and South Korea.

The new technology, based on major histocompatibility complex (MHC) tetramers, was first developed in mice and humans and has only recently been applied to livestock, says ARS microbiologist William Golde. For the first time, scientists can follow more complicated T cell immune responses in addition to B cells.

"Antigens for virus-specific T cells are actually very small peptides of viral proteins that are present in the MHC molecules, which are the tissue molecules," Golde says. "The technology is based on typing cattle, just like you type a human for an organ transplant

GLEN SCOLES (D2297-2)

GLEN SCOLES (D2298-1)

Left: Cattle at the International Livestock Research Institute (ILRI) in Nairobi, Kenya. ARS and ILRI scientists are working to develop a cattle vaccine to prevent transmission of East Coast fever (ECF), a tickborne disease. Below: At ILRI, *Rhipicephalus appendiculatus* ticks are injected in a test designed to reveal more about the tick's genes involved in infection and transmission of ECF.

and know exactly which molecules you're working with. The combination of MHC protein and viral peptide are made into tetramers that can then identify the responding T cell."

The goal is to demonstrate that MHC tetramers can be applied to vaccine development in cattle and create tools for working with livestock diseases, says Golde, who has used the technique in pigs. In those experiments, pigs were vaccinated either with a vaccine targeting T cells or another targeting B cells and then compared. Results showed that by redesigning vaccines to target T cells, a different kind of immune response to FMDV could be induced.

Golde is working with ILRI researchers to apply these tools to other important cattle diseases in Africa, like East Coast fever. Further, he is working to import cells producing monoclonal antibodies specific for bovine proteins used for analyzing the immune response in cattle. These were prepared at ILRI.

"These reagents will be imported, tested for safety, and used in further research at Plum Island to study the response to FMD," Golde says. "Once safety tested, they will then become available to the North American research community."

Mapping the genome of sheep for parasite resistance

Identifying genes in sheep, goats, and cattle that increase tolerance to gastrointestinal (GI) parasites and improve production of grazing animals is another collaborative effort of ARS and ILRI scientists.

These parasites cause economic and production losses. Infected sheep suffer from diarrhea, weight loss, and anemia, and some die.

The team is the first to detect quantitative trait loci (QTLs) in a double-backcross population derived from native sheep adapted to the extreme conditions of East Africa.

Researchers started a breeding program at ILRI more than 10 years ago to create a resource population for mapping regions of the ovine genome that control resistance to GI nematode parasites predominant to African regions. Breeding started with creating hybrid rams by mating a GI parasite-tolerant breed—Red Maasai—to a more susceptible breed—Dorper. Six of the hybrid ram offspring were then bred to either Red Maasai or Dorper ewes to complete the backcross.

"We genotyped 20 percent of the progeny of those matings to map QTLs affecting parasite resistance traits," says Tad Sonstegard, an ARS geneticist at the Henry A. Wallace Beltsville [Maryland] Agricultural Research Center. "Some of the sheep were 75 percent Red Maasai, and some were 75 percent Dorper."

Parasite indicators—blood packed-cell volume and fecal egg count—were collected on a weekly basis for 3 months from 1,064 lambs grazing on GI-nematode-infected pastures. Average packed-cell volume, which indicates whether sheep are anemic from blood-feeding parasites, and average fecal egg count, which indicates worm load and fecundity, were used to select lambs for genotyping.

Significant QTLs for average fecal egg count and packed-cell volume were detected on chromosomes 3, 6, 14, and 22.

In a follow-up study, scientists plan to genotype the same animals again using the OvineSNP50, which interrogates more than 50,000 locations in the genome, says Sonstegard. The previous study looked at only 200 locations.

"If we can identify some of the genes that increase tolerance to parasites or figure out the best combination of Dorper and Red Maasai from a genome-composition view, we can increase production, and maintain that adaptability to parasites," Sonstegard says. "This ultimately leads to better germplasm, which leads to better global food security."

Genetics Provide the Base for Crop Production

Crops such as potatoes, corn, wheat, rice, beans, and more are the staples that feed the world. For developing nations, they are often critical for survival. The task of providing varieties of these crops that can sustainably supply the needed nutrients is a high priority for agricultural research. Several of the CGIAR centers focus on these crops and others.

Partnerships for potatoes

In developing countries, the potato is a vital source of nutrients for humans. Pinpointing a potato species' true origin can help scientists find genes needed to improve potato production.

Botanist David Spooner (right) and Alberto Salas, plant genetic resources specialist with the International Potato Center, Lima, Peru, collect potato germplasm in Peru for deposition in national and international gene banks.

ALEJANDRO BALAGUER (K9020-20)

ARS researchers and their counterparts at the International Potato Center (CIP) in Lima, Peru, are combining geographic information with computer-based tools to analyze distribution data of wild potato species, which are native to the Americas.

Until recently, wild potatoes were not known to spread outside of their native range, which is from the southwestern United States to central Chile and adjacent countries.

Botanist David Spooner at ARS's Vegetable Crops Research Unit in Madison, Wisconsin, and his CIP colleagues found that the wild potato species *Solanum chacoense* has become established in seven nonnative sites around the world, including parts of China, England, Peru, Argentina, the United States, and New Zealand. They also found that a cultivated potato, *S. tuberosum,* is now established in the wild in Hawaii and Africa.

"A technique called 'environmental modeling' was used to show other places where *S. chacoense* might spread," Spooner says. "The technology enables us to look at relationships between taxonomy and diversity and at locations and habitats where most species are found."

Boosting beta-carotene in corn

Corn and wheat are eaten in some form or another by just about everyone on the planet. Scientists affiliated with the International Maize and Wheat Improvement Center (CIMMYT) near Mexico City, Mexico, are focused on increasing the productivity of maize and wheat production systems to ensure global food security and reduce poverty.

In many developing areas of the world, corn is a staple food. In areas where most daily calories consumed come from corn, people can suffer blindness and other serious health issues because of a lack of vitamin A.

Cultivated corn does contain some carotenoids, like beta-carotene, which are converted to vitamin A in the body. Raising the concentration of beta-carotene in corn would help fight vitamin A deficiency in those areas where other sources of carotenoids in the diet are severely limited.

ARS plant geneticists Ed Buckler of the Plant, Soil, and Nutrition Research Unit in Ithaca, New York, and Marilyn Warburton of the Corn Host Plant Resistance Research Unit in Mississippi State, Mississippi, have worked to identify the genes that different corn varieties use to make beta-carotene.

Warburton and Buckler analyzed many of the high beta-carotene corn lines in the CIMMYT genebank and from CIMMYT and U.S. maize breeders. Focusing on the biochemical pathway responsible for producing carotenoids in corn, they have identified which genes would increase the concentration of beta-carotene most efficiently. The most promising type of one of these genes came from tropical corn germplasm, while the best form of another gene in the same pathway came from temperate corn. "By knowing which temperate U.S. corn variety to cross with which tropical corn variety, we could create a variety that provided much higher beta-carotene levels than would have been identified using traditional plant-breeding methods," says Warburton. (See "Boosting Vitamin A Levels in Corn To Fight Hunger," *Agricultural Research,* May/June 2010.)

Improving yield and drought resistance

Buckler has also been working on finding genetic markers for accelerating yield improvement and drought resistance. "We have a National Science Foundation/Gates Foundation funded project with the CGIAR centers to reduce the cost of genotyping and make finding the markers less expensive than growing out the varieties in field trials," says Buckler. "We are making good progress on that."

"We are about to start genotyping all the important breeding lines of corn and

STEPHEN AUSMUS (D1905-6)

At the Corn Host Plant Resistance Research Unit, in Stoneville, Mississippi, molecular geneticist Marilyn Warburton and technician Jack Hayes use gel electrophoresis and fluorescent plate readers to identify plants with markers associated with traits of interest, which will allow the most efficient selection of corn plants with the beneficial traits.

Kenyan lines of sorghum show improved growth and yield on field plots with acidic soils outside Moi University in Kenya.

SAM GUDU, MOI UNIVERSITY (D1273-1)

sorghum found throughout sub-Saharan Africa over the next few months," says Buckler. "The genotyping data will be posted on public websites, including the CGIAR public website. But the real value is for breeders to take their data on yield and performance in various environments and find out if they can apply the genotyping data to make useful outcome predictions."

Making this process faster and less expensive is important. "Imagine if every time you want to know whether or not a corn variety meets your needs, you must grow it and measure it in 10 environments. This can cost hundreds of dollars. For $10 or $20, we can genotype that line and predict whether it will serve the breeder's needs," says Buckler. This can help narrow the field of potential candidate corn varieties. "Of the thousands of potential corn lines, we can focus on the 10 percent that are likely to be the best. This saves everyone effort and time," says Buckler.

"We are also involved with CIMMYT in the survey of all the corn varieties called 'landraces'—traditional or heirloom varieties that farmers grew before modern breeding techniques were applied. These landraces have been adapted to grow in specific locations all over North and South America. For the first time, we will analyze them systematically to try to start mining out the genetic variation by genotyping them," says Buckler.

Sharing rice germplasm to help feed the world

Rice is a staple in many diets across the globe, and ARS scientists have forged collaborations with their international counterparts to help enhance rice production. That, of course, means navigating various challenges growers face, such as diseases. ARS scientists at the Dale Bumpers National Rice Research Center (DB-NRRC) in Stuttgart, Arkansas, collaborate with scientists at the International Rice Research Institute (IRRI) to evaluate rice germplasm and improve disease resistance, yield, and grain quality. IRRI is headquartered in the Philippines.

It helps to know what different rice varieties have to offer for breeders in particular geographical regions. Rice genetic resources are stored in large germplasm banks around the world, such as the Svalbard Global Seed Vault in Norway, and those in the United States and the Philippines. Germplasm is also stored and studied in smaller collections at various research locations. ARS plant geneticist Georgia Eizenga has been exploring the genetics of rice varieties housed in the IRRI germplasm bank. "IRRI has more than 112,000 rice accessions, making it the largest collection in the world," says Eizenga. By comparison, the United States has nearly 19,000 rice accessions and supplied 400 of these to develop a "rice diversity panel." The diversity panel is a set of rice varieties that that have been collected from various stages in history and from different countries. Some are wild rice types that have been collected in different environments, and others are varieties recently developed by breeders.

"We grow the diversity panel and develop genetic markers to find out which genes are responsible for particular traits," explains Eizenga. "The first complete rice genome sequence was for a Japanese cultivar, Nipponbare, which serves as the reference genome." By comparing different rice varieties against the Nipponbare sequence, researchers can determine which markers are associated with specific traits, like flowering time, seed size, leaf length, and even how sticky the grains are after cooking. These visible traits are called "phenotypic traits." Phenotypic data, along with genetic markers, can provide information about which genes govern certain traits. This enables researchers to more efficiently conduct genetic research into important agronomic traits such as disease resistance, yield, and quality.

Examining rice genes at the molecular level

ARS plant pathologist Yulin Jia, also at DB-NRRC, researches the molecular relationship between rice and the fungi responsible for the diseases rice blast and sheath blight. "I visited IRRI a few years ago and was able to bring back more than 100 lines that contained different genes that confer resistance to the

In a field of rice in Columbia, plant molecular pathologist Yulin Jia looks for typical eye-shaped lesions of rice blast disease. The inset shows a lesion on the U.S. rice cultivar Katy inoculated with *Magnaporthe grisea*.

YULIN JIA (D542-1)

FERNANDO CORREA (D542-2)

blast fungus," says Jia. "Similarly, IRRI scientists have imported rice germplasm from the ARS collection for their research. Some of this germplasm has shown some resistance to sheath blight strains that occur in their environment."

Genes are constantly changing in order to survive, and over the years the genes in rice and fungi have co-evolved. "Resistance is relative to the specific pathogens. For instance, not all humans are immune to flu viruses, because new strains of flu emerge constantly. That is also true for fungal strains and the rice varieties they infect," explains Jia. "So as time goes by, the old resistance genes may not work against the new fungal strains."

The work has certainly paid off. "We characterized the molecular mechanisms of rice blast resistance—how it works and how resistance genes evolved. We have also mapped two major blast-resistance genes from a rice cultivar from China," says Jia.

New rice varieties

Rice quality is also an area of interest to breeders, growers, and researchers. ARS scientists in Arkansas and Texas, in collaboration with researchers at Texas A&M University, University of Arkansas, Clemson University, and IRRI, developed new varieties that offer new options for U.S. growers and expanded market opportunities for the U.S. rice industry.

Although conventional long-grain varieties are grown on more than 75 percent of the rice acreage in the United States, there is interest in developing cultivars that possess specific qualities required for certain value-added markets.

The variety JES is an aromatic, soft-cooking, long-grain rice suited for the market predominantly filled by imports. A jasmine-style rice, JES has greater yield, is 5 inches shorter, and matures a week earlier than Jasmine 85, a variety currently grown for this market.

Charleston Gold, another aromatic rice, was derived from Carolina Gold (an heirloom variety that was the basis for establishing the U.S. rice industry) and genetic material from the Philippines and India. It has excellent yield, disease resistance, and cooking quality. This cultivar may lend itself well to production under organic conditions and will be used by the historically authentic cuisine market in the Carolinas.

Breeding for disease-resistant chickpeas and lentils

Scientists at ARS's Grain Legume Genetics and Physiology Research Unit in Pullman, Washington, and the International Center for Agricultural Research in Dry Areas (ICARDA) in Aleppo, Syria, are exchanging breeding lines of germplasm to develop disease resistance and other agronomic characteristics.

"We're incorporating a lentil collection from ICARDA into our breeding program as a source of winter hardiness—cold tolerance—and virus resistance," says George Vandemark, ARS geneticist and research leader at Pullman. In turn, ARS is providing ICARDA with a special chickpea population.

"We developed a population of mutated chickpea lines, and they're really valuable genetic material," Vandemark says. "We don't have the resources to propagate the population, so our partners at ICARDA are going to increase it for us. They'll grow, harvest, clean, and store them."

Researchers at Pullman also work with colleagues at the International Crops Research Institute for the Semi-Arid Tropics in Patancheru, India, on studies that involve testing pest-resistant chickpeas. (See "Help for the Common Bean: Genetic Solutions for Legume Problems," *Agricultural Research,* May/June 2010.)

STEVE CLEMENT (D1787-1)

Entomologist Hari Sharma, of the International Crops Research Institute for the Semi-Arid Tropics, and a colleague in a chickpea research plot at the Regional Research Station, Kukumseri, in the Himalayan foothills of northern India.

Other work includes cooperative research with ICARDA that focuses on inheritance and mapping of lentil genes for resistance to rust and *Stemphylium* blight, two important diseases of lentil in Southeast Asia, says Weidong Chen, ARS plant pathologist at Pullman.

"We are trying to find DNA markers linked to genes for resistance to the diseases," Chen says. "We don't have lentil rust in the United States, but *Stemphylium* blight has been seen in North Dakota, other Northern Plains states, and adjacent Canada. So we have developed the tools to identify some of the candidate DNA markers for resistance."

Stem lesions on chickpea caused by the fungus *Ascochyta rabiei.*

GEORGE VANDEMARK (D2302-1)

PEGGY GREB (D509-1)

ARS plant pathologist Marcial Pastor-Corrales inoculates bean plants with spores of the bean rust fungus.

Finding genes to help bean growers

The International Center for Tropical Agriculture (CIAT) is headquartered in Cali, Colombia, and focuses on developing eco-friendly methods of producing crops. Plant pathologist Marcial Pastor-Corrales of the Soybean Genomics and Improvement Research Unit in Beltsville, Maryland, worked at CIAT for 17 years before coming to ARS and maintains close collaborative relationships with his former colleagues. Pastor-Corrales is working on improving common bean production, with an emphasis on discovering and incorporating genes for resistance to diseases, particularly common bean and soybean rusts. Common bean rust is a major constraint to bean production in most countries where dry and snap beans are produced, especially in eastern and southern Africa and Latin America.

"The CIAT Bean Germplasm Bank has the largest and most diverse common bean collection in the world, with some 36,000 accessions," says Pastor-Corrales. This diversity may be just what is needed to help with pathogens that are moving around the globe. "The common bean rust is a highly variable pathogen that is important worldwide. The various races of this pathogen change from one year to another, so we are always looking for new rust-resistant genes for common bean," he says.

In 2007, two new races of the common bean rust pathogen appeared in the United States, and many dry bean cultivars were susceptible to them. "We have found many new genes for resistance to several diseases, including common bean rust, from CIAT accessions. These are potentially very valuable," says Pastor-Corrales. "These collaborations can result in preventing problems in the United States and enhancing production and making it safer and more sustainable in other countries."

In the 2008-2009 growing season, the U.S. farm value of soybean production was $29.6 billion. A potential threat to this crop is the soybean rust pathogen, which arrived here in 2004. "Working with scientists from the USDA-ARS Foreign Disease-Weed Science Research Unit, we tested germplasm obtained from CIAT and found that some common dry beans were resistant to soybean rust," says Pastor-Corrales. "Because the soybean rust pathogen also infects common beans and other legumes, 16 lines of common dry beans were tested with 6 isolates of the soybean rust pathogen from Asia, Africa, and Latin America. We found 5 dry bean cultivars that were highly resistant to soybean rust. Wild accessions have more genetic diversity, so we would like to discover more resistance genes that can confer soybean rust resistance from these wild varieties to common beans and soybeans."

Meanwhile, in Puerto Rico, ARS plant geneticist Timothy Porch of the Tropical Agriculture Research Station in Mayagüez is working with CIAT scientist Rowand Chirwa and with scientists at the University of Puerto Rico and the Ministry of Agriculture in Angola on developing resistance to prevalent diseases in common bean for Angola. "The work began in 2007 and focuses on developing lines, for future cultivar release, with resistance to angular leaf spot, bean common mosaic virus, and common bacterial blight. There is a graduate student from Angola at the University of Puerto Rico performing this work on disease resistance in common bean and another graduate student studying cowpea diversity," explains Porch.

"We are using CIAT germplasm to develop and release lines with root rot

Soybean leaves infected with soybean rust.

CHRISTINE STONE (D521-1)

resistance and heat and drought tolerance that will be used to improve U.S. varieties of common bean," says Porch. "We are working on introducing novel traits and on converting tropical varieties to types that can be grown in the temperate U.S. region. This would require introducing photoperiod insensitivity to photoperiod-sensitive tropical type beans." That way, beans previously adapted to the 12-hour day-length of the Tropics will also be productive in the longer 16- to 18-hour photoperiods in the United States.

Collecting lentils from Nepal

Lentils are an important export crop for the United States and important food for the people of many nations. Geneticist Clarice Coyne of the ARS Plant Germplasm Introduction and Testing Research Unit in Pullman, Washington, manages lentil germplasm at the unit, which is also known as the Western Regional Plant Introduction Station (WRPIS). There are 3,247 lentil accessions at Pullman, but only 13 accessions are of lentil from Nepal.

In association with Ashutosh Sarker, a senior scientist with ICARDA, Coyne has developed a joint proposal to boost the number of lentil accessions in the WRPIS collection. An exploration trip is in the planning stages to collect lentil accessions from Nepal.

"We have an interest in lentil production in Nepal because they grow lentils at a high elevation. This means they will grow at a lower temperature than other lentils," says Coyne. "These plants may be adapted to colder temperatures, which would be helpful to lentil growers in the U.S. Pacific Northwest." Lentils could be grown as a fall-sown crop in Washington State. That would also help with soil erosion, which is a problem during the winter months.

It is important to collaborate with ICARDA because they have the expertise necessary to conduct a successful exploration trip in Nepal. "Their experts know where to find the lentils and they know their growing habits," says Coyne. "Also, a portion of the proposed funding would go to Nepal in order to develop their national germplasm collection."

Thwarting diseases of cacao

Cacao is the source of chocolate. Unfortunately, cacao is under attack by diseases like witches' broom, frosty pod, and black pod. ARS geneticist Raymond Schnell at the Subtropical Horticultural Research Station in Miami, Florida, is working with an international consortium to document genes and genetic markers that might lend resistance to these and, potentially, other diseases of cacao.

Working with the International Institute of Tropical Agriculture, Schnell and other international collaborators have developed 6,000 single nucleotide polymorphism (SNP) genetic markers, which are being used for marker-assisted breeding (MAB). The goal of MAB is to find SNPs or microsatellite markers associated with resistance to these diseases. Markers associated with resistance are then used to select for new cacao varieties with resistance. Using these markers greatly increases the efficiency of traditional breeding. Cacao cultivars that are resistant to these diseases will ensure that there will be a plentiful supply of cocoa beans for the confection industry.

PEGGY GREB (K9538-1)

Geneticist Raymond Schnell examines a cacao pod.

SCOTT BAUER (K8618-1)

Pathogenic fungi that cause witches' broom on cacao tree limbs and trunks also attack pods, destroying the valuable beans inside.

YUE JIN (D1797-1)

Ug99-infected wheat at a nursery in Njoro, Kenya.

In the breeding effort, Schnell and his collaborators have field trials under way in West Africa in Ghana, Cameroon, Nigeria, and Cote d'Ivoire. Field trials are also located in Ecuador, Brazil, Costa Rica, and Papua New Guinea.

The battle against Ug99 continues

The fight against a menacing strain of wheat stem rust—Ug99—is gaining momentum. The U.S. Agency for International Development is providing Feed the Future resources through the Norman Borlaug Commemorative Research Initiative for ARS to build a greenhouse at the Cereal Disease Laboratory (CDL) in St. Paul, Minnesota, as part of a collaborative effort to develop rust-resistant varieties. A groundbreaking ceremony was held in June 2011.

The greenhouse will greatly increase CDL scientists' ability to identify foreign wheat rust isolates from CGIAR centers, says CDL research leader Marty Carson. Research on Ug99 will be conducted under contained and authorized conditions.

Ug99 was discovered in Uganda more than a decade ago and has quickly spread throughout East Africa, Asia, and the Middle East. (See "International Wheat and Barley Screening Collaboration Helps Uncover Stem Rust-Resistant Material," *Agricultural Research,* February 2010.)

The disease now threatens food security in Pakistan and Afghanistan. ARS scientists will use the new greenhouse facility to help identify and verify unknown rust isolates and develop adapted rust-resistant varieties for Pakistan, which can also be used in Afghanistan, in partnership with CGIAR centers.

Other research on rust protection for wheat continues at ARS labs in Raleigh, North Carolina, and Pullman, Washington. (See "ARS Wheat Resistance Roundup," *Agricultural Research,* May/June 2010.)

"We need combinations of genes and more durable genes to protect wheat for years to come from these rusts," says Kay Simmons, deputy administrator of ARS's crop production and protection national programs. "That's why collaborative work between ARS wheat pathologists and geneticists with CGIAR centers is so important."

Field trials in Kenya to screen for resistance are vital to this work, according to plant pathologist Mike Bonman of the Small Grains and Potato Germplasm Research Unit in Aberdeen, Idaho.

Bonman worked at IRRI for 9 years before coming to ARS and is now working collaboratively with CIMMYT and KARI. Bonman and colleagues have screened more than 3,000 wheat landraces from the U.S. National Small Grains Collection against new races of the stem rust pathogen in the field in Kenya. A number of resistant accessions were identified and are being retested to verify their resistance. Landraces with confirmed resistance are being crossed with susceptible wheat to determine the genetic basis of the resistance.

"CIMMYT facilitates the nursery and site logistics, and ARS helps with evaluating the level of rust development in wheat varieties," says Bonman. "Without CIMMYT it would be difficult, and my team works closely with Sridhar Bhavani, the CIMMYT coordinator in Kenya, and with wheat breeder Peter Njau and plant pathologist Ruth Waynera, both from KARI."

"CIMMYT and KARI personnel have developed excellent procedures to promote rust disease in the nursery to enable us to evaluate which of our accessions are resistant to rust, but a lot depends on timing," says Bonman. "Knowing exactly when to evaluate, or rate, the disease is very important because different plant materials mature at different times, and landrace materials from the U.S. collection often mature late. A postdoctoral fellow in our lab, Maria Newcomb, was recently in Kenya to rate the off-season nursery, and we depended on Sridhar, Peter, and

PEGGY GREB (D948-1)

Plant pathologist Mike Bonman (left) and molecular biologist Eric Jackson examine wheat plants from the National Small Grains Collection in a stem rust screening plot at Aberdeen, Idaho.

Ruth to help us pinpoint the optimum time for her arrival.

"Our goal is to find new genes for resistance to Ug99, because the fungus overcomes many of the resistance genes we have been using for the past 50 years. This work will help Africa's growers now and will help suppress disease and reduce damage in developing countries. It will also prepare the United States for Ug99 should it reach our shores. This research is of great mutual benefit, and I am grateful for the outstanding assistance we receive from CIMMYT and KARI."

All of these research collaborations will help bolster food security across the globe. ARS and CGIAR will continue these endeavors for years to come.—By **Sharon Durham** and **Sandra Avant,** ARS.

This research supports the USDA priority of promoting international food security and is part of multiple ARS national programs, described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Sharon Durham, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1611, sharon.durham@ars.usda.gov.

KEITH WELLER (K6027-9)

GRIN-Global Brings Powerful Genebank Information System to Forefront

A better system to keep track of germplasm information will soon be available worldwide, thanks to a partnership between ARS, the Global Crop Diversity Trust, and Bioversity International (a CGIAR center). The Germplasm Resources Information Network (GRIN), an online database of plant genetic resources information developed by ARS, is going global.

KEITH WELLER (K6020-1)

GRIN-Global will replace GRIN, which is used by ARS's National Plant Germplasm System to actively manage information regarding plant genetic resources at various genebank sites. This Internet-based database system enables curators throughout the world to customize it to fit their specific needs and enables public researchers to access germplasm information and material.

"GRIN software helps curators keep track of the origins of the genetic materials they manage and their traits, properties, and inventory status—which seeds, plants, and tissues are available and how much," says Peter Cyr, information technology specialist and project leader at ARS's North Central Regional Plant Introduction Station in Ames, Iowa. "It also keeps track of who requests and receives seeds or plant material."

With GRIN-Global, other nations will have the option to access a free, easy-to-use system for documenting plant germplasm and delivering that information to researchers worldwide. Each genebank will have its own local version of the GRIN-Global software, including a customizable website that can support many languages.

The system is expected to be up and running in CGIAR centers and in several national genebank systems in 2011. It will be implemented in the United States by 2012. It will enable scientists, educators, and other germplasm users to be better informed and to choose precisely the samples that best meet their needs.—By **Sandra Avant,** ARS.

STEPHEN AUSMUS (K11611-2)

Beans (above), bok choy (middle), and carrots of many different colors (left) are just a sample of the variety of specimens in the Germplasm Resources Information Network (GRIN), which will soon be available to researchers worldwide as GRIN-Global.

A Better Way To Hatch CATFISH EGGS

Agricultural Research Service scientist Les Torrans has spent the bulk of his career in the Mississippi Delta looking for ways to help commercial farmers grow a better catfish or develop more efficient ways of feeding and harvesting them.

Now, with the U.S. farm-raised-catfish industry struggling in the face of cheaper foreign imports and rising production and feed costs, the scientist—based at the Catfish Genetics Research Unit of the Thad Cochran National Warmwater Aquaculture Center at Mississippi State University (MSU), in Stoneville—is focusing on new field research he thinks could provide some help.

In just the last year or two, Torrans says, the number of catfish hatcheries in his portion of the Delta has declined from 30 to just a dozen or so.

While growers have known for as long as there have been commercial catfish farms that aeration of ponds was critical for fish survival, Torrans provided empirical evidence on exactly how oxygen levels affect feeding and production in ponds. His research has produced new oxygen-management recommendations for ponds that can save energy and improve production.

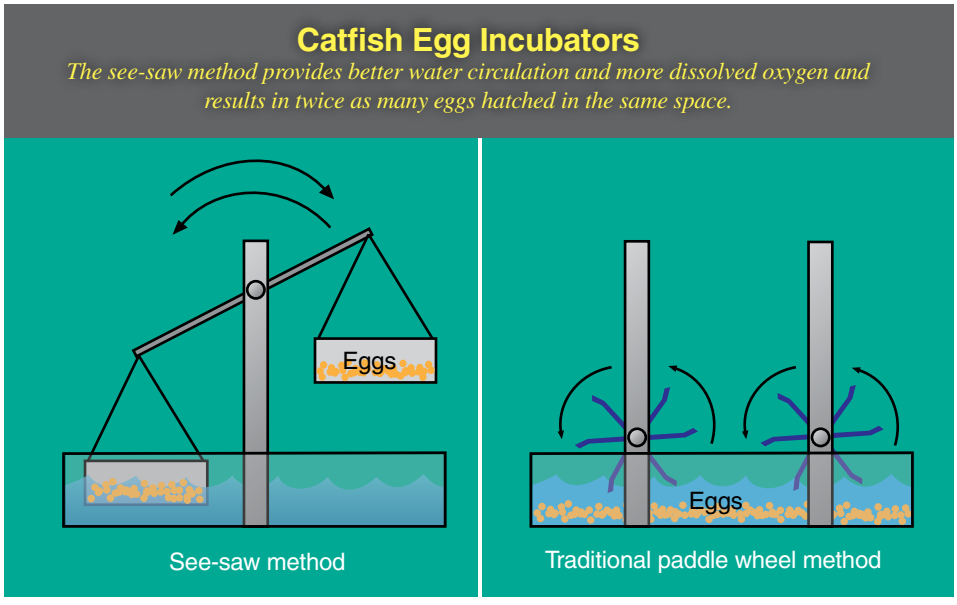
More recently, Torrans and MSU's James Steeby developed specific dissolved oxygen recommendations for catfish hatcheries. Data they collected on catfish egg and fry metabolism showed that most hatch variations are caused by insufficient dissolved oxygen in the water. Poor water circulation around and through egg masses, especially at high egg-loading rates, compounds the problem, according to Steeby and Torrans.

Now Torrans is applying his mechanical skills to building a high-intensity catfish egg incubator he calls a "see-saw." Torrans says the device will provide a better mix of dissolved oxygen for vulnerable catfish eggs by dipping the egg masses, much like a tea bag being dipped in water, then lifting them completely out of water before dipping them again. As long as the egg masses stay wet, they are able to exchange gas across the chorion (egg shell). Oxygen in air is much more abundant than oxygen in the water, so this innovative see-saw device takes advantage of the water dipping to maintain the developing eggs' moisture while using the air for oxygen delivery.

STEPHEN AUSMUS (D1929-5)

Catfish farmer Bobby Jones (left) and his father Robert A. "Shorty" Jones, of Needmore Fisheries LLC, observe the "see-saw" egg incubator with co-developer fish biologist Les Torrans (center). The two farmers plan to replace their traditional paddle-type incubators (seen on the right, behind Jones) with the new see-saw device before next spawning season.

C. BEUCHERT-ARS



"It looks like we can hatch more than twice as many eggs with the see-saw in the same space and use half as much water as with the traditional paddle-wheel method," says Torrans.

"What we're seeing is an industry in trouble in Mississippi, Alabama, Arkansas, and Texas, where more than 90 percent of the nation's catfish are grown," he says. "If we can get more dissolved oxygen to the eggs, more will hatch. That would obviously be a boost to farmers. We have to make our domestic production as efficient as possible."—By **Chris Guy,** ARS.

This research is part of Aquaculture, an ARS national program (#106) described at www.nps.ars.usda.gov.

Les Torrans is in the USDA-ARS Catfish Genetics Research Unit, 127 Experiment Station Rd., Stoneville, MS 38776-0038; (662) 390-3882, les.torrans@ars.usda.gov. ✻

Keeping Aquaculture Fish HEALTHY

JULIA PRIDGEON (D1938-1)

Immersion vaccines have been used for decades, but current work on developing alternative methods of vaccine delivery through feeding is promising. Here, molecular biologist Craig Shoemaker (left) and microbiologist Phillip Klesius demonstrate a technique where channel catfish are immersed in water containing the modified live *Streptococcus iniae* vaccine.

Keeping aquatic animals healthy in tanks, ponds, and cages is a critical aspect of fish and shellfish farming.

ARS scientists are researching various aspects of fish health, including genetic-based resistance to pathogens, treatments to cure diseases, and vaccines to prevent them.

Cold-water Disease Targeted

At the National Center for Cool and Cold Water Aquaculture (NCCCWA) in Leetown, West Virginia, one of the diseases researchers are investigating is bacterial cold-water disease, caused by the bacterium *Flavobacterium psychrophilum*. This disease is a longstanding problem in trout aquaculture, and methods for its control are limited. The disease was first described in 1948, and it occurs in salmon, trout, and a few other species. It often arises at low temperatures, and infected fish may display a range of clinical signs, including large, open lesions on the tail area as well as systemic infection. *F. psychrophilum* is considered one of the most important salmonid pathogens worldwide because of the large number of fish deaths caused by infection and the resulting economic impact among commercial aquaculture producers.

In 2003, NCCCWA molecular biologist Greg Wiens and microbiologist Tim Welch began talking to industry trout producers about their issues and concerns, and cold-water disease came up most often. "We worked closely with industry partner Scott LaPatra at Clear Springs Foods in Idaho, and obtained *F. psychrophilum* strains from his facility," says Wiens. "We sequenced the genome of one strain and used this information to design PCR [polymerase chain reaction] assays to measure genome variation. Now we can better distinguish between isolates, and we are trying to determine the impact these different variants have on trout disease resistance."

Fish can be infected simultaneously with multiple strains—up to three pathogen strains were found in a single fish. Studies

CINDY LEDBETTER (D1937-1)

Catfish infected with Ich, caused by *Ichthyophthirius multifiliis,* a protozoan parasite that is responsible for the white spots on the fish.

are under way to test the responses of fish when exposed to *F. psychrophilum* variants.

To mitigate the pathogen's impact, Wiens has been working since 2005 to selectively breed rainbow trout for improved resistance to bacterial cold-water disease. "It is a large project involving many scientists and personnel at our facility," including geneticist Tim Leeds, computational biologist Roger Vallejo, and Jeff Silverstein, who is now the national program leader for ARS's national program on aquaculture.

"After two generations of selection, we found there was a 45-percent improvement in survivability of the resistant trout," says Wiens. "Small-scale field trials are currently under way in Utah and Idaho to determine how well our fish perform on farms when they are subjected to natural challenge with the pathogen. A larger field trial is planned for 2011." These resistant lines will offer breeders a genetic resource for improving disease resistance in commercial populations.

Wiens and his colleagues also noticed something quite interesting about the resistant fish: They have larger spleens. The researchers have now found that spleen size is highly heritable and that there is a genetic correlation with bacterial cold-water disease resistance. Understanding the relationship between resistance and spleen size may provide clues to help researchers select for resistance more rapidly and may reveal important insights about the immune response generally. They are now trying to map the rainbow trout genes affecting disease resistance and variation in spleen size. These genetic studies are being conducted by geneticist Yniv Palti and center director Caird Rexroad III.

"Ichy" Fish

Dave Straus in Stuttgart, Arkansas, is researching treatments to control disease on catfish, specifically Ich and fungi. "Ich" is short for *Ichthyophthirius multifiliis,* a protozoan parasite that at maturity appears as white spots on infected fish—the scourge of anyone who has owned an aquarium. Because catfish don't have scales, they are particularly vulnerable to this parasite.

"Ich is considered the most prevalent parasite worldwide in ornamental fish, baitfish, and food fish," says Straus, an aquatic toxicologist at the Harry K. Dupree Stuttgart National Aquaculture Research Center. "It is less common in U.S. aquaculture because of management techniques, but when it occurs, it can kill all the fish in a pond or raceway. Based on results of a 2003 survey, it was calculated that Ich was directly responsible for $1.2 million in losses to the catfish industry."

The freshwater fungus *Saprolegnia* is another major pathogen in fish culture, killing eggs and invading wounds and lesions on juvenile and adult fish.

One effective treatment for Ich on fish and fungus on eggs is copper sulfate. Straus's lab conducted research to determine effective doses for each use. "Copper sulfate is the only practical treatment to control Ich in catfish ponds that average about 10 acres in area. It is easy to use, effective, inexpensive, and safe to the person using it," says Straus. "Approved treatments for fungus on eggs—formalin and hydrogen peroxide—are much more expensive; both compounds are hazardous, and there are human safety concerns as well as storage precautions."

During the life cycle of Ich, only the free-swimming stage is susceptible to treatments. Once Ich attaches to the fish, it burrows under the skin, and copper sulfate treatments are rendered ineffective.

"Copper sulfate is not approved by the U.S. Food and Drug Administration (FDA) for therapeutic use in aquaculture, but regulatory action has been deferred pending the outcome of ongoing research at our lab," says Straus. "Copper sulfate is approved by the U.S. Environmental Protection Agency as an algicide and molluscicide. Fish farmers use copper sulfate to control cyanobacteria that cause off-flavor in fish and to control snails that transmit parasitic flatworms to fish."

Straus is working with corporate sponsor Freeport-McMoRan Copper and Gold of Phoenix, Arizona, to obtain FDA approval to use copper sulfate as a treatment for Ich in earthen production ponds and as a fungicide on eggs in catfish hatcheries. Research has recently been completed for all technical sections for both label claims—control of Ich on catfish and fungus on catfish eggs.

"All technical sections are complete for the approval for Ich in catfish except for the environmental safety. We plan to resubmit the environmental assessment to the FDA by the end of the year with the additional information the agency requested," says Straus.

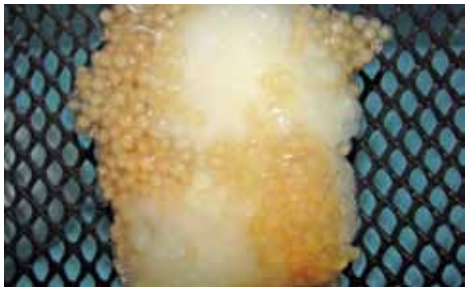
There's a "Vacc" for That

Advances in research, including new fish vaccines developed to tackle pathogens such as *Streptococcus iniae* and *S. algalactiae,*

DAVE STRAUS (D1935-1)

Healthy catfish eggs treated with copper sulfate.

DAVE STRAUS (D1936-1)

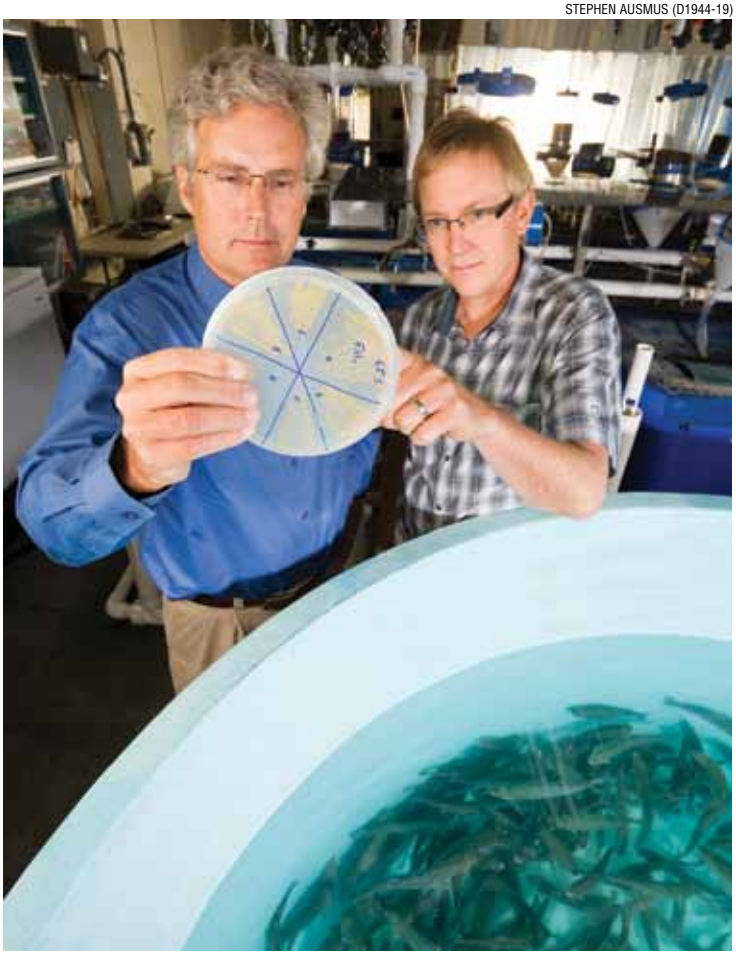


Fungus on catfish eggs not treated with copper sulfate.

STEPHEN AUSMUS (D1162-12)

Fish lab manager James Everson (left) and ARS geneticist Yniv Palti collect rainbow trout fingerlings to evaluate growth rate and resistance to disease.

STEPHEN AUSMUS (D1944-19)



ARS molecular biologist Greg Wiens (left) and ARS microbiologist Tim Welch examine a culture of *Flavobacterium psychrophilum,* a bacterial pathogen of rainbow trout.

could help protect America's aquaculture industry when it needs it most.

Scientists at the ARS Aquatic Animal Health Research Unit in Auburn, Alabama, and its worksite laboratory in Chestertown, Maryland, are developing vaccines to protect farm-raised catfish and nearly two dozen other aquatic animal species that are vulnerable, says microbiologist Phillip H. Klesius.

Klesius, research leader at Auburn, working with colleagues Joyce J. Evans in Chestertown and Craig Shoemaker and Julia Pridgeon in Auburn, has been recognized with several professional awards for innovative work over the past decade. Their successful vaccine against the pathogen causing enteric septicemia of catfish has been widely adopted across the catfish industry.

"We have been producing vaccines using modified live bacteria that are no longer viable pathogens," Klesius says. "We've been able to patent several vaccines in the last 10 years and then license them to private firms."

Researchers have made the process of modifying the genetic makeup of pathogens to make them nonvirulent seem almost routine. They are now able to develop vaccines that expose fish or other animals to low doses of modified forms of the pathogen, which allows the fish to build up a lifelong immunity. "We use a live, modified vaccine that has enough similarity with the pathogen to create immunity," says Klesius.

Streptococcus presents a serious threat to the industry. The pathogen is ubiquitous and can occur in wild fish and in food fish. It can be found on almost any size farm. Pridgeon and Klesius have developed a modified live *S. iniae* vaccine that appears to be superior to inactivated or killed vaccines.

A technique in which fish are immersed in water containing the modified pathogen has been used to vaccinate large numbers of fish, but current work on developing alternative methods of vaccine delivery through feeding are promising.

Through field trials conducted in 1996 in 10 ponds on a commercial farm, David Wise, a research professor at Mississippi State University, and retired scientist Kurt Schuster found that the vaccine for enteric septicemia of catfish increased the survival rate of the fish by more than 12 percent. Their study also showed that producers using the vaccine could expect returns to increase by $1,800 per acre.

Klesius, Evans, Pridgeon, and Shoemaker are working with an eight-member research team to determine genetic variation in response to vaccines and pathogens, study disease progression in fish infected with multiple pathogens, develop more sophisticated ways to detect pathogens, describe how immunity—innate and acquired—works in aquatic animals and find opportunities to enhance it.—By **Sharon Durham** and **Chris Guy,** ARS.

This research supports the USDA priorities of ensuring food safety and promoting international food security and is part of Aquaculture, an ARS national program (#106) described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Sharon Durham, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1654, sharon.durham@ars.usda.gov. ✻

Studying Streambanks Reveals Their Weaknesses and Strengths

When some experts study bank failures, they aren't scrutinizing the books of badly run financial institutions. Instead, they're occasionally wading through Mississippi's sediment-laden waterways to develop dynamic models of erosion processes and streambank collapse.

"The problem is that the primary source of sediment in many Mississippi streams and rivers is from streambank failure, not from field runoff," says Agricultural Research Service hydrologist Glenn Wilson, who works at the ARS Watershed Physical Processes Research Unit in Oxford, Mississippi. "Up to 80 to 90 percent of sediment in these streams can be due to bank collapse."

The sedimentation of streams, rivers, and other waterways is a global concern, and the U.S. Environmental Protection Agency lists sediment as the most common pollutant of U.S. rivers, streams, lakes, and reservoirs. Trapped sediment can reduce the useful lifespan of dams and reservoirs, exacerbate flooding, harm aquatic plants and animals, and transport other pollutants downstream. So over the years, billions of dollars have been spent on streambank protection and restoration efforts to stem erosion and reduce sedimentation loads.

Even though the sediment in streams and rivers is often attributed to erosion and runoff from farm fields, Wilson turned his investigations to the contributions of streambank erosion. He teamed up with Oklahoma State University scientist Garey Fox to study how seepage—the lateral movement of water through the ground—could prompt conditions that led to bank failure.

GLENN WILSON (D2063-1)

An example of seepage erosion from a section of Goodwin Creek in Mississippi.

Wading Through the Data

The researchers started their project with a field survey of streambanks that were severely undercut and prone to collapse. "This type of undercutting has historically been attributed to streamflow," Wilson says. "Others have noted that during high-flow events, the increased speed and volume of the streamflow cuts into the bank and weakens it. Then when the water level drops, the bank fails."

But Wilson and Fox found examples of undercut bank failures that had occurred in low-flow streams. When they took a closer look at these banks, they saw evidence that seepage out of streambanks was eroding out layers of soil. The eroded soil layers washed down the face of the streambank and into the stream itself, adding to the sediment load in the stream and leaving the bank weakened and vulnerable to collapse due to having undercuts from the washed-out layers.

"When we were first looking at this, bank stability models didn't account for subsurface flow—just for surface water flow," Wilson explains. "So our existing streambank models were actually missing key mechanisms in bank failure."

The scientists gathered enough field data on seepage erosion processes to develop lab models and refine their understanding of how seepage could exacerbate eventual streambank failure. In the lab, they could control bank depth and seepage flow rates—and they could safely observe the sometimes-sudden collapse of a massive wall of dirt.

GLENN WILSON (D2062-1)

ARS hydrologist Glenn Wilson (left), graduate student Raja Periketi (center), and Oklahoma State University scientist Garey Fox use a simulated streambank to conduct laboratory experiments of seepage erosion on streambank failure. Periketi is measuring the lateral extent of a mass failure caused by seepage erosion.

"Streambanks can be 10 to 20 feet high, and the subsurface seeps can form at any depth," Wilson says. "We couldn't measure peak seepage rates in the field under all the conditions we'd like because it was just too dangerous—the banks collapse during storms, and sometimes they're deep enough to bury you."

Wilson and Fox confirmed for the first time that a stable streambank can quickly become unstable when seepage erosion is added to the mix of factors that promote bank failure. The probability of failure reached 100 percent when the degree of undercutting reached about 30 to 50 millimeters (1 to 2 inches) into the bank face. The researchers concluded that streambank failure may stem as much—or more—from the effect of seepage erosion undercutting the streambanks as from the added weight of the waterlogged soil as seepage increases.

Wilson included their calculations into the Bank Stability and Toe Erosion Model, a program developed at the ARS National Sedimentation Laboratory that calculates the likelihood of streambank failure for new or existing banks and simulates the efficacy of different approaches for protecting the streambank from erosion. "Our big payoff for this research has been recognizing and understanding the seepage erosion process and how it contributes to bank failure," Wilson says. "Looking back, I'd say the biggest surprise from this work is that the role of seepage had been overlooked for so long."

Putting Green Stuff in the Bank

Down the hall, ARS geologist Natasha Bankhead has also been studying streambanks, but she's focusing on how removing mature plants can weaken the structures—and how adding young riparian plants can support them. "Plant roots reinforce the soil in the same way that rebar can be used to reinforce concrete," Bankhead says.

Plants vary in their effectiveness as streambank sentinels. Grasses have thin, dense roots that form an underground net and can protect the soil on shallow banks from eroding. Taller banks need more substantial reinforcement, but trees don't always fit the bill.

"Trees don't have much of an impact on bank stability until they're around 7 to 10 years old," Bankhead says.

As part of her research, Bankhead is testing the tensile strength of roots—the force required to pull a root to the point where it breaks—of different tree species. Her studies indicate that in the southeastern United States, willows and other primary succession trees growing along streambanks have lower tensile strength levels. Trees that are part of the later successional stages, like sycamores, river birches, oaks, and cottonwoods, have higher tensile strengths. But the root structures don't just provide physical support.

"In the summer, trees remove a huge amount of moisture from soil through evapotranspiration," Bankhead explains. "And bank stability increases as soil moisture decreases, so in the summer, the effect from evapotranspiration actually provides more structural support to the streambanks than the roots do."

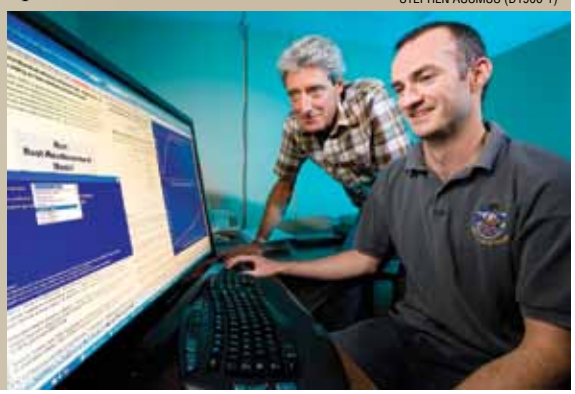
Bankhead has used her findings to develop a program called "RIPROOT," which models the effects of riparian vegetation on streambank stability. She is collaborating with other researchers to test it in watersheds across the country.

"We've made a lot of advances in understanding these processes and incorporating them into mechanistic, process-based models," Wilson says. "But we need to continue collaborations with soil scientists, geotechnical engineers, hydraulic engineers, and hydrologists to fully understand and integrate subsurface-flow and soil-erosion processes."—By **Ann Perry,** ARS.

This research is part of Water Availability and Watershed Management, an ARS national program (#211) described at www.nps.ars.usda.gov.

Glenn V. Wilson and Natasha L. Bankhead are in the USDA-ARS Watershed Physical Processes Research Unit, 598 McElroy Dr., Oxford, MS 38655; (662) 232-2927 [Wilson], (662) 281-5712 [Bankhead], glenn.wilson@ars.usda.gov, natasha.bankhead@ars.usda.gov.

STEPHEN AUSMUS (D1906-1)



ARS geologist Andrew Simon (left) and University of Tennessee-Knoxville scientist Robert Thomas use the RIPROOT model, a component of the Bank Stability and Toe Erosion Model, to estimate the effects of riparian vegetation on streambank stability.

150 Years of Making History

USDA's 150th Anniversary

May 15, 2012

The only thing that stands between the United States and an invasion of cattle-killing screwworms is a daily flight of airplanes flooding a 100-mile-wide section of the Isthmus of Panama with male screwworm flies raised in a laboratory and sterilized with radiation in Panama. The screwworm infestations of the past would probably come back if the releases stopped for a couple of months or so, says Dan Strickman, Agricultural Research Service national program leader for veterinary and medical entomology.

"This is a great example of agricultural research changing the history of this country, and it's a cutting-edge example of integrated pest management," Strickman adds.

This year marks the U.S. Department of Agriculture's 150th anniversary, making it a particularly appropriate time to look at this and other examples of history in the making.

The screwworm was wiped out of the United States by 1966 and Mexico by 1991. The purging continued south to include Central America until the "barrier" reached across the entire narrow Isthmus of Panama, and the screwworm was declared eradicated from Central and North America.

Before USDA eradicated the species from the United States, the screwworm—larvae of which eat living tissue of people and other animals—had plagued the Southwest, all of Florida, and parts of Georgia.

In 1937, the late Edward F. Knipling, then at a USDA laboratory in Menard, Texas, got the idea of flooding areas with sexually sterilized male screwworm flies. He believed that by releasing large numbers of sterile male flies, they would mate with nonsterile female screwworm flies and that the resulting "unsuccessful" mating would decrease the population over time, driving the flies to extinction.

When Knipling came up with the idea, there was no known way of sterilizing the male flies. Then one day he read an article by the Nobel Prize-winning geneticist Hermann Joseph Muller in *Scientific American* showing that x-rays sterilized male fruit flies without interfering with their normal functions.

Knipling wrote to Muller to see whether x-rays could be used to sterilize screwworm flies. Muller wrote back immediately, indicating his interest in the idea.

That exchange—and subsequent experiments demonstrating that the idea worked, including research by colleague Raymond Bushland showing that sterile male screwworms could be raised in a laboratory and function normally after release, including mating with nonsterile females—led to the historic screwworm eradication program.

The sterile insect technique has been used to eradicate screwworms elsewhere, including north Africa—where they were accidentally introduced—in the 1990s and most recently from Aruba. The technique has proved useful in controlling other pests as well, such as the Mediterranean fruit fly and the tsetse fly.

USDA screwworm research began under the auspices of the department's Bureau of Entomology and Plant Quarantine, which was transferred to the Agricultural Research Administration (which became the Agricultural Research Service by the end of 1953). The laboratory at Menard

Flesh-eating screwworms once plagued some southern U.S. states but have been eliminated from and kept out of the country because of continuing efforts of USDA scientists.

APHIS (D1742-1)

SCOTT BAUER (K7023-6)

Mediterranean fruit fly, a worldwide agricultural pest, is controlled by the same techniques used to eliminate screwworms.

was incorporated into the U.S. Livestock Insect Laboratory in 1946, which, in 1988, was renamed the Knipling-Bushland U.S. Livestock Insects Research Laboratory in honor of the two pioneering scientists. The facility, located in Kerrville, Texas, works on cattle fever ticks, horn flies, stable flies, and other livestock pests. Live screwworms are not allowed in the United States, however, so the lab can only work with DNA from the screwworm. The live-screwworm work is performed at the Screwworm Research Unit in Pacora, Panama, the site of a huge factory that produces sterile males for release. The Kerrville lab continues to research effective, less expensive methods to control insect pests of livestock.

Keeping Soil Where It Belongs

Another example of USDA research changing history occurred in 1938, when the USDA Soil Conservation Service [now the Natural Resources Conservation Service (NRCS)] and the Texas Agricultural Experiment Station created a laboratory in Bushland, Texas, in the wake of a dramatic wind erosion event. Poor agricultural practices for years, coupled with severe drought, left the soil of extensive U.S. farmland exposed. The result was a multiyear period of severe dust storms in the 1930s. Known as the "Dust Bowl," it was characterized by thick, black clouds of dirt and dust stretching across several states and millions of acres.

The Bushland lab's charge was to prevent the intolerable conditions of another potential Dust Bowl and to minimize wind erosion, working with other state experiment stations—such as those in Kansas and Ohio—and other USDA labs.

They developed stubble mulch tillage, leaving the residue of harvested crops on the land over winter to keep soil from blowing away and to save precious soil moisture. This was the forerunner of the highly successful practice of no-till and other forms of conservation tillage that drastically reduced erosion, whether by wind, rain, or snowmelt. ARS research was spurred further by the drought of the 1950s. At the time, there were limitations to stubble mulch, mainly lower yields, so ARS set out to overcome those limitations and, in time, succeeded in making conservation tillage an NRCS-recommended "best practice."

ARS Bushland scientists continue conservation tillage research to this day, improving techniques and adjusting to modern challenges. They have learned to harness wind energy to produce electricity for use in homes and on farms. They continue research on water conservation, taking advantage of the latest technology. Today, that means getting information on soil moisture from satellites.

Conservation tillage practices were developed by USDA scientists to keep soil in its place. The abundant residue on the soil of this no-till cotton crop planted into an unplowed cornfield will help prevent erosion from wind and rain.

DAVID NANCE (K7520-9)

GEORGE E. MARSH, NOAA, DEPT. OF COMMERCE (D2520-1)

NOAA, DEPT. OF COMMERCE (D2519-1)

Top: A dust storm approaching Stratford, Texas, in 1935. Above: Wind erosion in the Dust Bowl lasted for years in the 1930s, moving dramatic amounts of valuable soil—enough to practically bury this farm machine.

It is unlikely that the Great Plains will suffer another Dust Bowl as severe as the one in the 1930s. Isolated yet significant storms are inevitable, but the conservation tillage and crop residue management techniques developed from ARS research will certainly reduce the severity of dust storms in agricultural regions.

Six Nutrition Research Centers and Four Regional Research Centers

USDA-ARS human nutrition research also changed the history of the nation and continues to do so. This research has long affected the daily lives of Americans, although the average person may not realize it. Let's start with breakfast: The calorie content, fat percentage, and nutrient content on the label of the cereal box are required by the U.S. Food and Drug Administration (FDA), using ARS data that traces back to the work of Wilbur Olin Atwater, the father of American nutrition, in 1894. He began the food analysis that today is listed on food containers. He also pioneered the surveys of people's eating habits that continue to the present. Today, nutrition research is carried out by six ARS human nutrition centers in Arkansas, California, Maryland, Massachusetts, North Dakota, and Texas. For example,

SCOTT BAUER (K7242-20)

Dozens of improved products and new varieties of fruits, nuts, and vegetables emerge from the laboratories and greenhouses of the Agricultural Research Service.

definitive human feeding studies at the Beltsville, Maryland, center showed the health benefits of limiting trans fat consumption. This led to FDA requiring food labels to include trans fat content and to food companies reformulating products to lower their trans fat content.

Ironically, nutrition research in the early days was directed at making sure Americans got enough to eat; today, research has to deal with obesity problems as well.

Many new products in the home—both food and nonfood—were a result of USDA-ARS research beyond the human nutrition labs. Many of these were from research efforts at four regional research centers established in 1938 to find new uses for agricultural commodities. Today, all four of these centers are designated American Chemical Society historical landmarks for specific scientific achievements. Those centers, strategically located across the country—in California, Illinois, Louisiana, and Pennsylvania—were created to help end chronic farm depression by finding new, value-added uses for surplus crops. By the end of 1940 and early 1941, research began at the centers, and many new value-added products—still in use today—were created as a result.

Adding lactose-free milk to cereal? ARS technology is used to make that milk. That glass of orange juice made from frozen concentrate tracks to ARS's development in the 1950s of a way to freeze the concentrate. Popping a frozen waffle in the toaster? ARS developed techniques for freezing that waffle and other foods. ARS scientists began a project in 1948 that eventually led to nine principles for freezing vegetables that remain the industry standard. Jelly on toast? ARS had a hand in developing jelly from fruits.

More recently, ARS worked with industry partners to develop a process for making sunflower seed butter as an alternative to peanut butter for children allergic to peanuts. "Frozen orange juice, sunflower seed butter, and lactose-free milk are probably among the top food and drink products developed with ARS technology in terms of dollar value in sales," says David Klurfeld, ARS national program leader for human nutrition.

USDA-ARS successes from research conducted at the centers also include instant mashed potatoes, explosion-puffed dehydration technology used to dry foods, and the SuperSlurper starch-based product used in making super-absorbent diapers, baby powder, wound dressings, automotive products, and agricultural and horticultural products, to name a few. The list goes on:

a coating to keep fresh-cut fruit, like apple slices, from browning, now available at fast-food restaurants and grocery stores; Oatrim fat substitute made from oat bran, used in ice cream and other foods to lower fat and calorie content; Sucromalt low-glycemic sweetener used in some food products to help consumers stabilize and lower blood sugar levels; soy-based fuels, inks, and hydraulic fluids; and compostable bowls, cups, plates, and trays.

People who wake up between cotton sheets and put on cotton clothing—whether permanent press, wash-and-wear, or flame-retardant—may not realize that they are benefiting from ARS research on improving cotton quality, processing, and use.

The invention of durable press helped the cotton fabric industry reinvent itself after World War II. Since then, USDA-ARS research has also led to wash-and-wear and flame-retardant cotton fabrics.

SCOTT BAUER (K4549-1)

The War Effort and Beyond

ARS researchers started shaping history immediately, and their efforts supported the United States and allies in World War II. In 1940, ARS chemists in Peoria, Illinois—at the request of Great Britain—found a way to produce penicillin, discovered in 1928, as a powder suitable for medicine. Then they found a way to produce the drug in quantity, using their expertise in growing molds in large fermentation vats. By the end of 1942, 17 U.S. firms were making penicillin pills.

Sunflower seed butter is one of many products developed as a result of ARS research. It offers children allergic to peanuts another alternative.

PEGGY GREB (D2515-1)

Peoria researchers found a superior, more productive *Penicillium* strain on a moldy cantaloupe from a local market. They gave that mold to the drug companies, and the companies produced enough penicillin to treat allied soldiers wounded on D-Day.

The Peoria lab's expertise and techniques have been used in developing many other products—including the food thickener xanthan gum, biobased fuels, and other biobased products—and in modern genetic research.

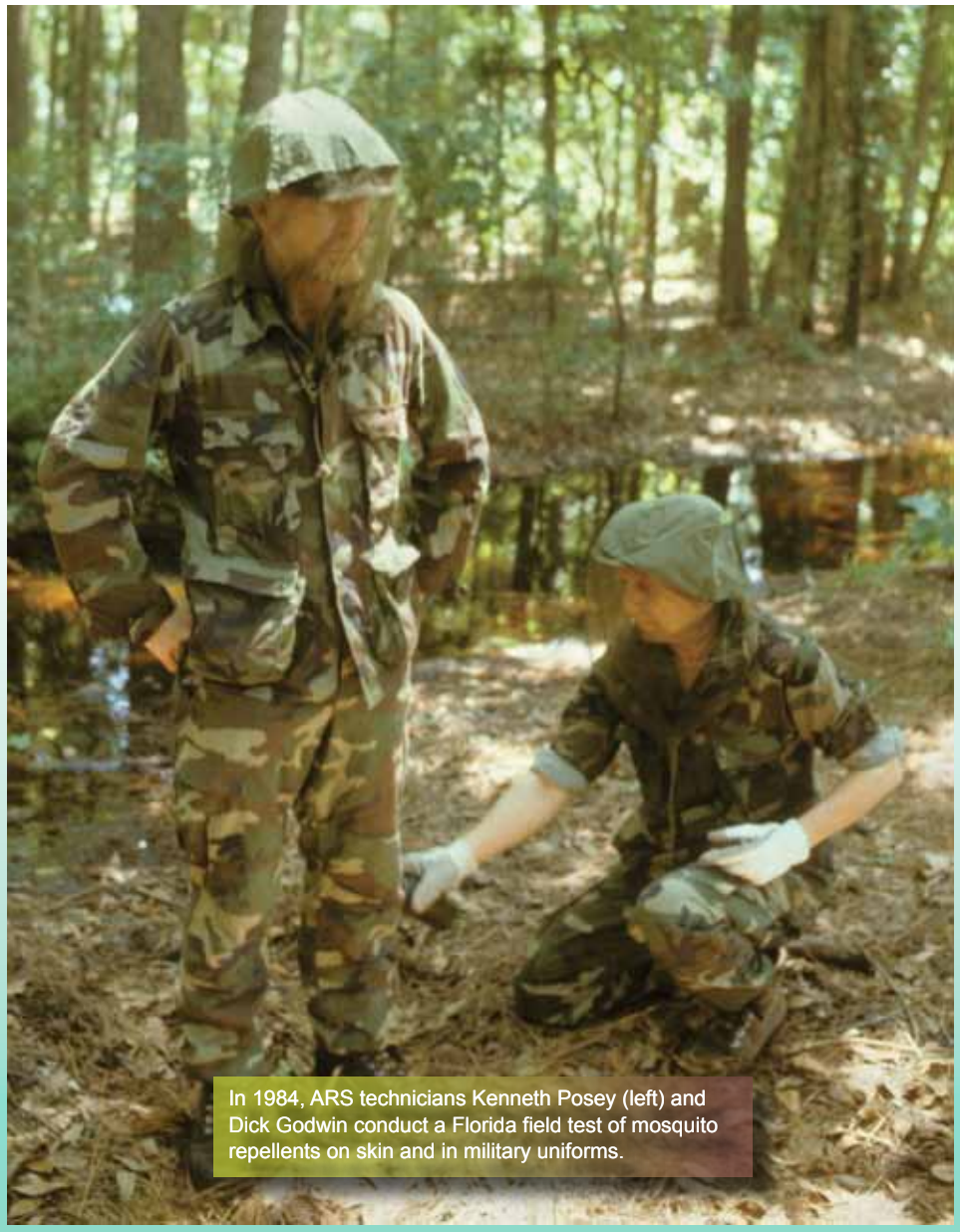
As part of the U.S. Emergency Rubber Project during World War II—aimed at finding domestic rubber sources—research at Wyndmoor, Pennsylvania, and other USDA labs helped improve the production of synthetic rubber. Their research was essential to the Allied victory, and remains useful to this day for producing domestic rubber.

In his Peoria laboratory, USDA scientist Andrew Moyer discovered the process for mass producing penicillin.

(K9422-1)

ARS researchers developed DEET to repel mosquitoes and other pests during wartime while looking for alternatives to citronella—which was in short supply at the time. ARS also came up with techniques for making military clothing resistant to biting insects, mildew, rot, and oil-based liquid chemical weapons. Other wartime discoveries included better bandages, dextran (a blood plasma substitute made from sugar beet pulp and sugarcane), and MRE (Meals Ready to Eat) food items for the military.

Many of ARS's discoveries and techniques developed during wartime have led to peacetime uses that have extended to today.



In 1984, ARS technicians Kenneth Posey (left) and Dick Godwin conduct a Florida field test of mosquito repellents on skin and in military uniforms.

(K1654-18)

Abundant, Safe Food

ARS research has always had an international aspect. Perhaps the best example is the work leading up to the Green Revolution—a period of increased worldwide agricultural production. In 1946, an ARS agronomist collected seeds of short-statured wheats in Japan. These seeds were later distributed to various U.S. wheat breeders, including a team led by ARS breeder Orville Vogel, in Pullman, Washington. The group developed high-yielding, semi-dwarf wheat varieties that were further improved by the late Norman Borlaug, of the International Maize and Wheat Improvement Center, to avert famines worldwide.

Upton Sinclair's *The Jungle,* an exposé of meat-processing practices of the past, resulted in the Meat Inspection Act of 1906 and the beginnings of a formal food safety agency at USDA. Although USDA-ARS research has always had a food safety aspect, a formal national research program was created in 1997 with the Food Safety Initiative under President Bill Clinton.

Today, ARS's food safety research includes robotic inspections of poultry and goes beyond meat to include all foods. A good example is an effort over the past decade by ARS researchers at Clay Center, Nebraska, and their colleagues. These scientists have been sequencing genes to find those that can be used as markers for serotypes of *Escherichia coli* that produce Shiga toxin. Through this work, they have worked with industry partners to develop assays for Shiga toxin-producing *E. coli,* including *E. coli* O157:H7, which causes foodborne illness.

This food safety program traces back to earlier research: A USDA chemist in 1882 was one of the first to analyze the bacterium that causes tuberculosis. USDA scientists over the years also showed the value of pasteurizing milk and determined the cooking temperature needed to kill the pathogen that causes trichinosis.

The Objectives of USDA's First Leader

By signing a bill on May 15, 1862, President Abraham Lincoln established USDA. From there, history moved swiftly as the Morrill Land Grant College Act (July 2, 1862) was signed, authorizing public land grants for colleges to teach agriculture and mechanic arts and leading to the establishment of major state-operated agricultural research centers.

On July 1 of the same year, Isaac Newton was appointed the first commissioner of agriculture. The new commissioner listed seven original objectives in his first report as head of the new department. In 1889, USDA achieved cabinet status, and these seven objectives have continued to be pursued by the department's agencies to the present day.

(D2521-1)

A researcher examines strawberry cultures in a growth chamber in the 1980s.

KEITH WELLER (K7898-3)

Developed by ARS agricultural engineer Yud-Ren Chen, this automated system could help speed inspection of the billions of U.S. chickens processed annually.

7 Objectives of Isaac Newton, USDA's First Commissioner of Agriculture

1. Collecting, arranging, and publishing statistical and other useful agricultural information.
2. Introducing valuable plants and animals.
3. Answering inquiries of farmers regarding agriculture.
4. Testing agricultural implements.
5. Conducting chemical analyses of soils, grains, fruits, plants, vegetables, and manures.
6. Establishing a professorship of botany and entomology.
7. Establishing an agricultural library and museum.

Today, USDA continues to fulfill these objectives, and many more. ARS is particularly involved in objectives 2, 4, 5, and 7. Other USDA agencies are more involved with objectives 1, 3, and 6.

"Testing Agricultural Implements"

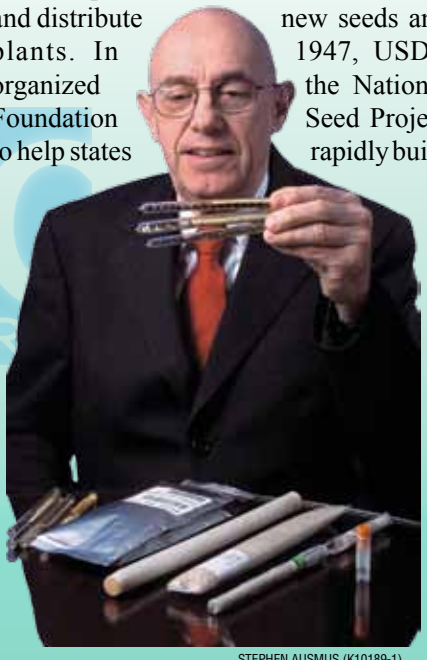
"Testing agricultural implements" was one of Newton's seven original objectives.

The National Soil Dynamics Laboratory, originally founded as the Farm Tillage Machinery Laboratory in 1933, is located on the campus of Auburn University in Auburn, Alabama. The lab was initially charged with researching tillage, associated traction practices, and machines used in cotton production, but its scope was soon extended to include all types of tillage, traction machinery, and practices. In 1957, the laboratory became the National Tillage Machinery Laboratory.

In its first 50 years, the laboratory contributed to the understanding of soil compaction and its management. In 1990, the American Society of Mechanical Engineers and the American Society of Agricultural Engineers designated the laboratory as a historic landmark.

Collect, Test, and Distribute New Seeds and Plants

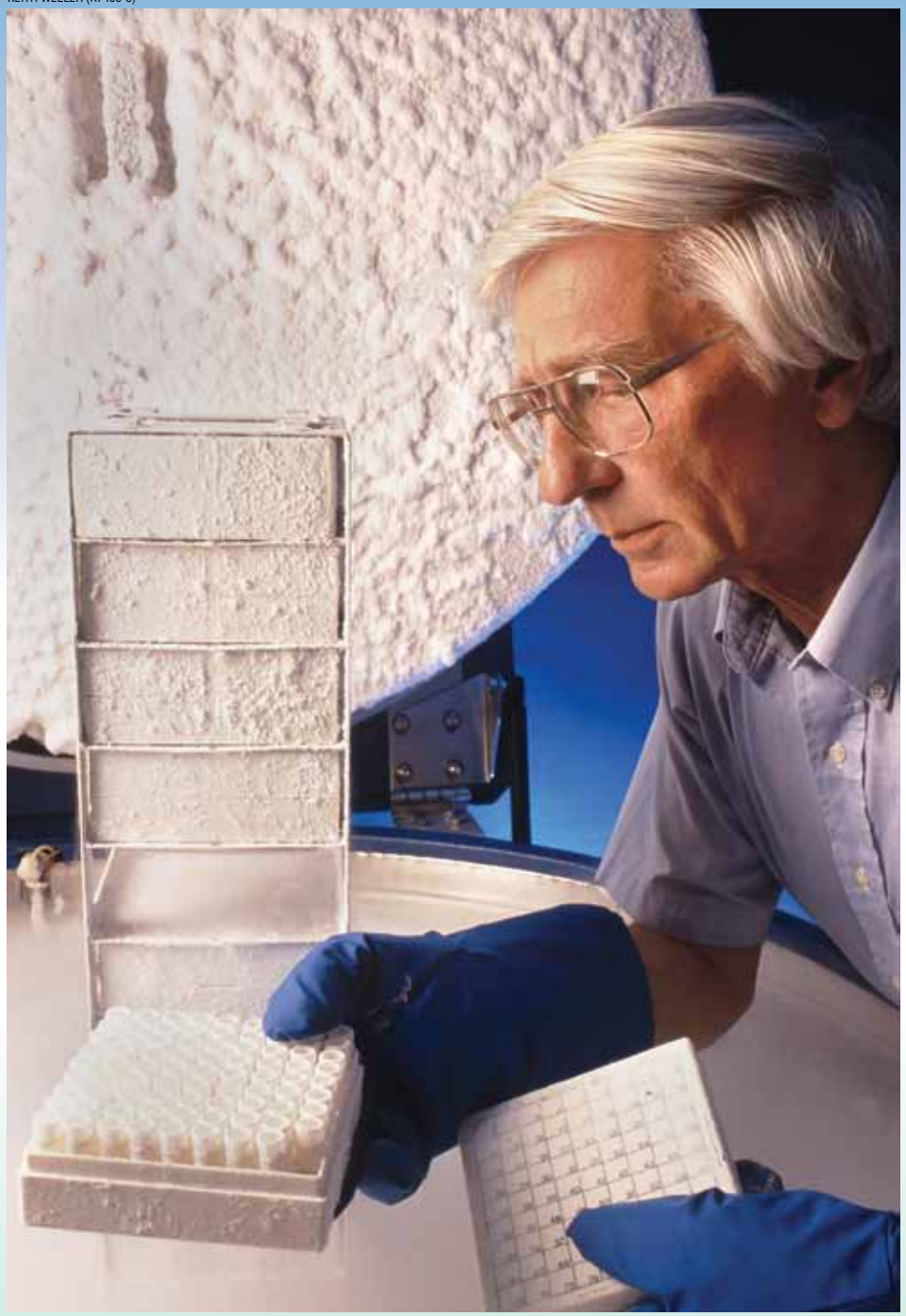
The law that President Lincoln signed to create USDA authorized Newton and future department leaders to collect, test, and distribute new seeds and plants. In 1947, USDA organized the National Seed Project Foundation to help states rapidly build



STEPHEN AUSMUS (K10189-1)

At ARS's National Center for Genetic Resources Preservation in Fort Collins, Colorado, Henry Shands holds tubes from a long-term experiment designed to test the effects of storage receptacles and temperature on seed longevity.

KEITH WELLER (K7406-3)



ARS's germplasm collections preserve more than just plants and animals for future generations. Here, microbiologist Cletus Kurtzman retrieves yeasts stored at an extremely cold temperature (in liquid nitrogen) in the ARS Culture Collection.

up seed supplies. Today, ARS maintains a national system of seed storage banks, the National Plant Germplasm System. The system's 20 genebanks and support units hold germplasm for scientists, breeders, farmers, and others to use. "Germplasm" refers to the parts of plants and animals that are needed for reproduction, like seeds or semen.

More than half a million germplasm samples from around the world are stored in containers housed in secure vaults at the National Center for Genetic Resources Preservation (NCGRP), formerly known as the National Seed Storage Laboratory—the central bank of the system. The seeds are stored at low temperatures—either 0˚F or over liquid nitrogen at –292˚F. Each of the 19 other genebanks contains certain species of plants, whereas NCGRP contains backup versions of them all and is the only one that also stores animal germplasm.

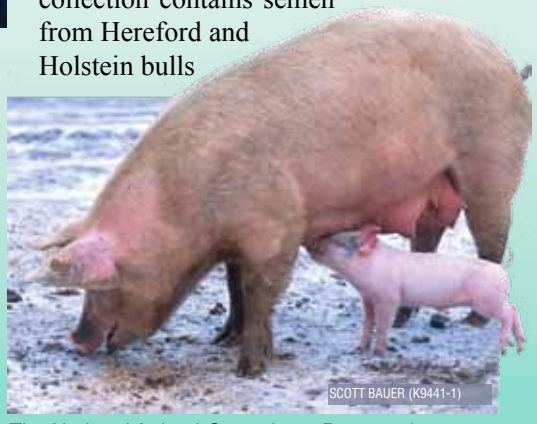
"Introducing Valuable Plants and Animals"

Another of Newton's seven goals was "Introducing valuable plants and animals."

Over the last 150 years, numerous scientific discoveries and research milestones have contributed to U.S. animal and plant production, ensuring that our foods are abundant, safe, and sustainable. In that tradition, ARS's ability to respond to our nation's needs—either in adapting to food security threats or in offering solutions to consumer needs—is also evident in groundbreaking research that saved and helped revolutionize several industries.

In 1833, hog cholera (also known as "classical swine fever") was first reported in the United States. Highly contagious to pigs and wild boar, the disease continued to spread, devastating the swine industry and ultimately jeopardizing pork production. Demonstrating its ability to respond in a crisis, ARS established the Hog Cholera Research Station in Ames, Iowa. The Ames station conducted research and diagnostic services on hog cholera until the National Animal Disease Laboratory opened in 1961 and later became the flagship for USDA's animal disease work. This lab continues to study major poultry and livestock diseases to help protect our nation's meat and poultry supply.

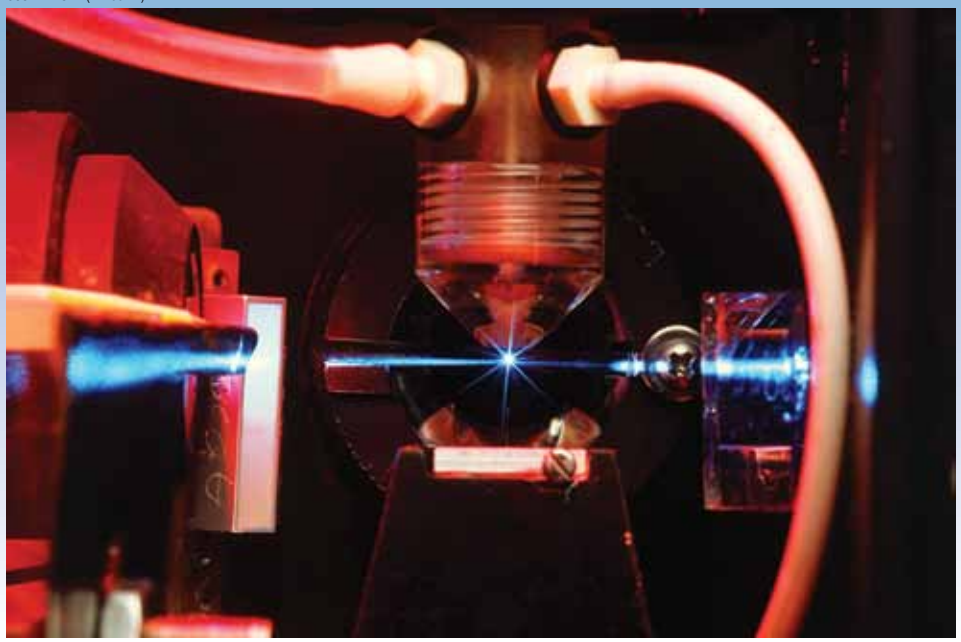
Germplasm collections preserve valuable genetic material for future generations. One of the many benefits of saving precious germplasm is protection against devastating diseases and pests and identification of important traits. The National Animal Germplasm Program houses animal germplasm from animals past and present. The collection contains semen from Hereford and Holstein bulls



SCOTT BAUER (K9441-1)

The National Animal Germplasm Program houses genetic material for swine and many other animals as an "insurance policy" against devastating diseases and other problems that might arise.

SCOTT BAUER (K4288-12)



The ARS-developed Beltsville Sperm Sexing Technology uses a fluorescent dye and a laser to identify and sort livestock sperm that will produce female progeny from those that will produce males.

from the 1950s to today. In addition, the repository has acquired semen samples from Limousin, Simmental, and Salers bulls that were originally imported from Europe in the late 1960s. Most recently, the repository has acquired a broad array of genetically diverse samples of Jersey cattle from Jersey Island, where the breed originated and from where it was first imported into the United States in the 1800s. The repository also houses germplasm from numerous sheep and swine breeds, including some from as far back as 1965. These collections serve as germplasm "insurance policies" for the animal production industries, protecting against loss of valuable germplasm diversity.

In 1935, USDA initiated its National Poultry Improvement Plan to improve production and marketing qualities of chickens and turkeys through performance testing. Years later, a major milestone was reached, changing the meat quality of turkey: ARS released the Beltsville Small White, a small, meaty, full-breasted turkey, in 1941. This bird met consumer needs and demands for a smaller turkey. Before the Beltsville Small White, the average weight of an adult tom turkey was a whopping 33 pounds. Some breeds were too big to fit in apartment-sized ovens and refrigerators. Thanks to USDA, today's turkeys and chickens—enjoyed year round—are extremely efficient and yield an abundance of lean meat.

In 1917, USDA started a long-term dairy herd improvement program that has led to a tremendous increase in milk production. The program continues to this day under ARS and is setting the standard domestically and internationally for genetic and genomic technology development and implementation.

The ARS Hereford cattle improvement breeding program began in 1934 in Miles City, Montana. Today the average Hereford contains more than 40 percent genetic material from the ARS Line 1 Hereford cattle. Research in beef cattle genetics at the U.S. Meat Animal Research Center quantified the value of numerous breeds and crosses for the beef industry. This research was extremely valuable and was used to develop most industry crossbreeding programs. Beef industry research in efficiency, reproduction, meat quality, and genetics is ongoing at ARS.

USDA scientists have changed the food industry—developing vaccines, processes, and technologies to protect our food, from the farm to our tables. When Marek's disease posed a threat to the poultry industry, ARS poultry scientists in East Lansing, Michigan, were first to develop a way to vaccinate chicken embryos against the disease. This disease attacks birds' nervous systems and kills more birds than any other disease. In 1987, ARS entered into its very first cooperative research and development agreement (CRADA) with Embrex Inc., of Research Triangle Park, North Carolina. This was the first

Beltsville Small White turkey. Released in 1941 by USDA, this turkey met consumer needs for a smaller bird with more breast meat.

(K9639-1)

CRADA between any private company and government lab under the Federal Technology Transfer Act of 1986. The act allowed more flexibility in federal-industry research and development. ARS licensed its egg-infection technology to Embrex, which enabled the company to innoculate 20,000 to 50,000 eggs per hour.

Other research has led to vaccines for H1N1 influenza virus, foot and mouth disease, mastitis, porcine reproductive and respiratory syndrome, avian leukosis virus, and brucellosis.

Aquaculture is an industry that provides half of the world's seafood. ARS's aquaculture program has proven invaluable to U.S. fish farmers, from improving production practices to breeding and improving fish varieties, like catfish, salmon, trout, and tilapia, to developing new vaccines to ensure healthy fish. Notably, ARS scientists in Auburn developed several vaccines that protect fish against major diseases, like those caused by *Streptococcus iniae* and *Flavobacter columnaris,* emerging bacterial pathogens in cultivated catfish, tilapia, hybrid striped bass, rainbow trout, and others. These vaccines offer alternatives to antibiotics or chemical treatments.

PEGGY GREB (K9216-9)

Market-size catfish ready for harvest. ARS scientists have developed vaccines that protect catfish, tilapia, hybrid striped bass, rainbow trout, and other fish from major diseases. The vaccines offer alternatives to antibiotics or chemical treatments.

Groundbreaking animal research includes inventing highly sophisticated breeding techniques and tools. ARS researchers developed, patented, and licensed the Beltsville Sperm Sexing Technology—a method that separates female-producing sperm from male-producing sperm based on DNA content. The technique helps speed the rate at which farmers can achieve genetic improvement while reducing production costs. More recent achievements include working with industry and university partners to develop a BeadChip, a genomic method used to analyze cattle DNA—and now sheep, pig, and plant DNA—to identify bulls that produce offspring with optimum milk production and other traits.

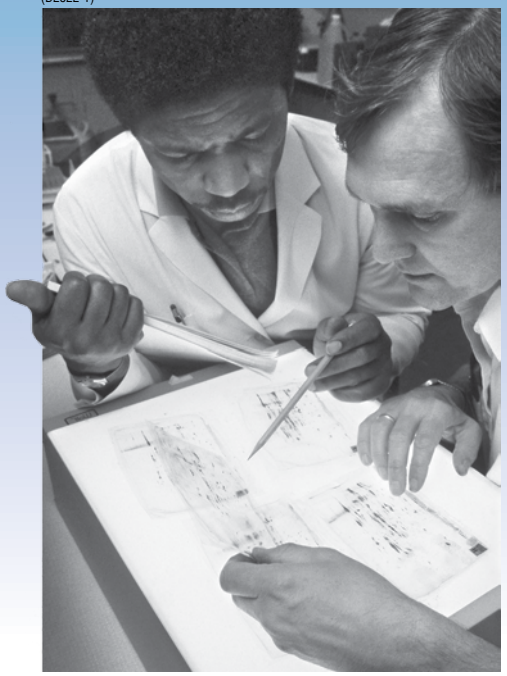
USDA scientists have conducted decades of crop production research to ensure a sustainable bounty of fresh fruits, vegetables, and other staples, like peanuts, wheat, rice, and soybeans—all while protecting our environment.

PEGGY GREB (K8666-1)

USDA scientists have conducted decades of crop production research to ensure a sustainable bounty of fresh fruits, vegetables, and other staples, like peanuts, wheat, rice, and soybeans—all while protecting our environment. Many new varieties of fruits and vegetables—including grapes, oranges, blueberries, cranberries, peaches, apricots, tomatoes, watermelon, potatoes, carrots, lettuce, cucumbers, peppers, apples, and more—were developed at USDA-ARS labs.

Red seedless table grapes were all but unknown to the U.S. consumer before USDA-ARS released the seedless grape Flame in 1973. In 1989, ARS released Crimson, which further increased table grape popularity. These two varieties alone, grown extensively by both domestic and foreign producers, make up a majority of today's consumer market, although several

(D2522-1)



KEITH WELLER (K4616-1)

SCOTT BAUER (K7246-1)

ARS is always working to improve the foods you consume. Left: Researchers in the 1980s examine protein profiles of soybean cultivars.

Center: Most of the U.S. citrus grown today was developed from ARS varieties or rootstock and is high yielding and disease resistant.

Right: Today's carrots, onions, garlic, and cucumbers—thanks to ARS research—taste better and have more nutrients.

newer USDA-ARS varieties have also taken hold of the U.S. table grape industry: Autumn Seedless, Thompson, Sweet Scarlet, Scarlet Royal, and Autumn King.

More than 70 percent of the citrus grown in the United States is from ARS-developed varieties or rootstock. ARS researchers in Florida have developed citrus that is high yielding, disease resistant, more colorful, and has a longer shelf life. Current research efforts are focused on protecting the U.S. citrus crop from citrus greening disease, one of the most severe citrus diseases.

Alone or with other partners, ARS conducts important environmental studies across the United States. A University of Maryland PhD student collects water samples from the Choptank River Watershed.

PEGGY GREB (D1878-1)

Nearly every head of iceberg lettuce you'll find in a supermarket owes its parentage to the work of ARS plant breeders. The ARS gene bank contains more than 2,000 types of lettuce. Researchers in California recently released three new leaf lettuce breeding lines with resistance to corky root, a serious disease of lettuce.

Blueberries, a nutritional power fruit, were not always the stars they are today. In the Gulf Coast region, growing blueberry crops is possible, thanks to ARS early-ripening varieties. Today, more than 10,000 acres are planted to Dixie—an ARS-developed variety—with more than 4,000 acres thriving in Texas, Louisiana, and Alabama. ARS researchers are now studying the compounds in blueberries and other berries and the effects of those compounds on nutrition and health.

Potatoes are popular whole, sliced, diced, mashed, or chipped. ARS's potato breeding program continues to deliver new varieties that are resistant to various diseases and pests and are high in nutrition. Recent research also targets zebra chip disease, a problem for potato growers since it was detected in 2000. Since then, it has

caused millions of dollars in production and processing losses.

These are but a few of many examples of the successful fruit and vegetable research at USDA-ARS. One cannot visit a supermarket or farmers market without encountering a fruit or vegetable that got its start at ARS.

"Establishing an Agricultural Library"

Newton's original goals also included "establishing an agricultural library." This goal was an outgrowth of the 1862 act that established USDA and ordered the commissioner "to acquire and preserve . . . all information concerning agriculture." Newton wasted no time. By 1863, around 1,000 volumes from the Agricultural Division of the Patent Office were moved to USDA to form the nucleus of this new library. After 100 years of service, it was designated the "National Agricultural Library" (NAL) and moved to Beltsville, Maryland.

Today, while that building still houses seemingly endless stacks of papers, books, and other items, the library's real growth comes digitally, with new, often specialized content finding its way to the Web for NAL's global customers. The NAL Digital Collections currently delivers nearly 25,000 USDA full-text publications, 45,000 scholarly articles, and the 7,584 technically accurate watercolor paintings, prints, and drawings of fruits and nuts that comprise the USDA Pomological Watercolor Collection. This ever-growing collection knocks down the barriers to finding government-produced agricultural research and informative historical works.

Under development is NAL's Life Cycle Assessment Digital Commons. It collects data that reflects how products derived from agriculture are grown, made, and used. Currently, such life cycle data is dispersed and often difficult to find, but the Digital Commons will bring that data from across the agricultural sector into one easy-to-use location.

"Conducting Chemical Analyses of Soils, Grains, Fruits, Plants, Vegetables, and Manures"

Newton's goal of "Conducting chemical analyses of soils, grains, fruits, plants, vegetables, and manures" is now done with technology beyond Newton's imagination. ARS scientists at Beltsville developed the Beltsville Universal Computerized Spectrophotometer, which led to near-infrared instruments to analyze and grade bulk grains like wheat and corn—as well as perform forage quality tests, manure analysis, and switchgrass grading for ethanol potential. Researchers continue to expand these techniques to develop cost-effective ways to rapidly improve bioenergy crops.

ARS researchers are also using innovative remote sensing techniques to develop close-up, hands-off inspection of meat and poultry, fruits, vegetables, and whole-kernel grains. Recent developments include an automated hyperspectral image analysis system—which uses digital imaging and visible/near-infrared spectroscopy—that can scan 140 poultry carcasses per minute during food safety inspection. Similar systems are used for quality inspection and detecting contaminants in fruits, vegetables, and grain to reduce their potential for causing foodborne illnesses.

ARS continues its research in these and other areas with an emphasis on lessening our global footprint. USDA researchers are learning more about how weather, climate, and water resources affect agricultural production and the environment. Today, USDA researchers and industry and university partners work collaboratively to explore environmental practices that will benefit farmers, consumers, and the world.

At USDA's sesquicentennial, ARS and all the other agencies that make up the department today are continuing to follow Newton's "Seven Commandments"—but with ever-changing technologies and challenges, most of them unimagined in 1862.—By **Don Comis,** formerly with ARS, **Tara Weaver-Missick,** ARS, and **Robert Sowers,** ARS.

Watercolor in the Rare and Special Collections of the National Agricultural Library.

(K9982-11)

Below: Outdoors and indoors, ARS scientists tackle a variety of problems. Left: Agronomist Edgar E. Hartwig devoted half a century to soybean research, developing productive plants with resistance to insects, nematodes, and diseases. Right: Biophysicist Moon Kim tests a portable imaging device equipped with a head-mount display for sanitation inspection of food-processing equipment.

KEITH WELLER (K5272-2)

STEPHEN AUSMUS (D611-1)

STEPHEN AUSMUS (D2320-9)

Entomologist Juan Morales-Ramos (left) and insect production worker Matthew McDaniel use a scaled-down prototype of a separator they designed to sort mealworms by size.

Coming to a

The wormlike nematodes from the genera *Heterorhabditis* and *Steinernema* are less than 1 millimeter long. But don't let their small size fool you: Both can bring down prey many times their size. People, plants, and pets aren't on the menu, though—only the larval stages of Japanese beetles, vine weevils, root borers, fungus gnats, and other insect crop pests.

Heterorhabditis and *Steinernema* species belong to a small but elite group of entomopathogenic (insect-killing) nematodes whose host-specificity has made them appealing biological alternatives to synthetic pesticides. Liquid formulations, wettable powders, and clay carriers are among products used to apply the nematodes and keep them safe during storage. About 10 years ago, however, an ARS team found that the nematodes perform best when applied to soils while still ensconced in the dead bodies of the insect hosts used to mass-produce them. (See "The Living Dead: What Lurks Inside These Insect Cadavers?" *Agricultural Research,* May 2002, p. 14.)

ARS entomologist David Shapiro-Ilan did that research with colleagues from ARS and the Virginia Polytechnic Institute and State University in Blacksburg, Virginia, and elsewhere. Shapiro-Ilan is with the Southeastern Fruit and Tree Nut Research Laboratory in Byron, Georgia.

Their approach uses the insect cadavers as a kind of staging ground from which nematodes can venture out when conditions are optimal—or at the prompting of specific chemical cues from their dead host.

Upon locating and penetrating their prey, usually via natural body cavities, the nematodes release symbiotic bacteria. They, in turn, liquefy the insect's innards, killing it in 24-48 hours. The nematodes feed on the "bacteria-seasoned" remains until all that's left is an empty shell. Within a week or two, a new generation of juvenile nematodes emerges, ready to start the cycle over again.

An Idea Takes Shape

A technical hurdle that's kept the insect-cadaver approach from gaining widespread commercial acceptance is the tendency of some commonly used host insects—notably the soft-bodied greater wax moth larvae—to rupture or stick together during storage, transport, and application.

To address this issue, Shapiro-Ilan teamed with Louis Tedders of Southeastern Insectaries, Inc., in Perry, Georgia, and entomologists Juan Morales-Ramos and Guadalupe Rojas—both with ARS's Biological Control of Pests Research Unit in Stoneville, Mississippi.

The result of that collaboration was an automated system that—in "Dr. Seuss-like fashion," as Shapiro-Ilan describes it—plucks nematode-infected insect cadavers from a container and deftly sandwiches them between two strands of masking tape. Eventually, an entire roll is formed, allowing for easy storage, transport, and application to pest-infested soils—whether in crop fields, orchards, greenhouses, or gardens.

Customized Insect-Cadaver Taping

Tedders, who had been collaborating with the ARS scientists under a cooperative research and development agreement, originally came up with the cadaver-taping idea. He also devised a prototype machine to automate the process, which Morales-Ramos and Rojas later refined to reduce labor and to standardize the final product. A patent application was filed in 2010.

Field Near You: Taped Insect Cadavers

Choosing the best insect species to use proved a critical early decision. Wax moth larvae had long been the nematode host of choice among insectaries and biopesticide companies, but the cadavers proved unsuitable for taping. "They become fragile and leaky; they're difficult to handle," says Morales-Ramos. Instead, the team chose mealworms, whose harder shells can withstand the rigors of carcass taping.

Using off-the-shelf parts purchased from the food-service industry, the Stoneville researchers built a prototype separation device that has blowers and customized screens to mechanically sort the mealworms by size. Previously, this had been done using hand-held screens, which was time-consuming. "Mealworms develop at different rates," says Morales-Ramos. "The biggest are chosen for nematode infection. Medium-size ones are sold for other purposes. Smaller sizes are returned to the colony to continue growing."

The mealworms are then placed in shallow plates teeming with hungry nematodes. After a few days, during which the nematodes infect and kill their hosts, a mechanical arm reaches in and places the carcasses between two strips of masking tape at the rate of one insect every 2 seconds. Future versions of the machine could speed the process by placing multiple cadavers simultaneously.

Testing Proves Tape Formulation's Worth

The next step was to test the tape-delivery system's ability to protect the cadavers from mechanical damage as well as its nematode yield and pest-control efficacy. "We found that infective juvenile nematode yield was not negatively affected by the tape formulation," says Shapiro-Ilan.

In laboratory experiments, the group measured survival of two insect pests, the root weevil or the small hive beetle, after the application of two nematode-infected hosts with or without tape in soil-filled 15-centimeter pots.

A greenhouse experiment was conducted in a similar manner to measure survival of the root weevil. "In all experiments, both the tape and no-tape treatments caused significant reductions in pest-insect survival relative to the control, and no differences were detected between the nematode treatments," says Shapiro-Ilan. "Fifteen days after application, the infected-host treatments caused up to 78-percent control of small hive beetle in the lab, 91-percent control of root weevil in the lab, and 75-percent control of root weevil in the greenhouse. These results indicate potential for using the tape-formulation approach for applying nematode-infected hosts."—By **Jan Suszkiw** and **Sharon Durham,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

To reach scientists featured in this article, contact Jan Suszkiw, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1630 [Suszkiw], (301) 504-1611 [Durham], jan.suszkiw@ars.usda.gov, sharon.durham@ars.usda.gov.

Inside this plump wax moth cadaver are thousands of wiggly nematodes ready to serve as biocontrols against soil-dwelling crop pests. Wax moth larvae cadavers proved too fragile for the new carcass-taping method, however, so mealworms are used instead.

PEGGY GREB (K9867-1)

STEPHEN AUSMUS (D2321-3)

Entomologists Juan Morales-Ramos and Maria Guadalupe Rojas view first-instar larvae through a microscope and evaluate the fertility of the mealworms to determine the effectiveness of diet formulations.

Protecting Corn Crops from Aflatoxin

Aspergillus flavus and *A. parasiticus* are naturally occurring soil fungi that are capable of invading food and feed crops and contaminating them with aflatoxin. Aflatoxin is a human carcinogen produced by the fungi and is also toxic to pets, livestock, and wildlife.

In addition to the safety hazard posed by aflatoxin contamination, the fungi place a significant economic burden on food and feed industries to ensure that contaminated products are prevented from reaching the food and feed supply.

Agricultural Research Service (ARS) researchers in Georgia, Mississippi, and Louisiana are looking at different approaches for control of aflatoxin contamination: One is "competitive exclusion"—using benign strains to impede colonization by harmful strains—and the other is developing corn germplasm that resists buildup of aflatoxin.

Who'll Win This Competition?

Recently retired microbiologist Joe Dorner at the National Peanut Research Laboratory in Dawson, Georgia, helped develop Afla-Guard, a biological control for *A. flavus* and *A. parasiticus* in peanuts.

Afla-Guard is composed of hulled barley coated with spores of a nontoxic strain of *A. flavus*. The nontoxic *Aspergillus* fungi successfully compete against the toxic species for the limited space and nutrients each needs to grow and thrive. In peanuts, Afla-Guard reduced aflatoxin by an average of 85 percent in farmers' stock peanuts and up to 97 percent in shelled, edible-grade peanuts.

In light of this success, Dorner and other ARS scientists conducted a 2-year study of Afla-Guard in corn. They again found that it was effective in reducing aflatoxin levels—showing an overall reduction of 85 percent, when compared to the levels found in control fields.

Afla-Guard was applied to the corn crop in different ways: to soil when corn was less than a meter tall, in plant whorls prior to tassel formation, and as multiple sprays during silking.

"Afla-Guard has shown that it has a place in reducing aflatoxin in corn crops," says Dorner. "After extensive study and research trials in Texas, Afla-Guard was registered by the U.S. Environmental Protection Agency (EPA) for use on corn, and that began with the 2009 crop."

Neutralizing Mycotoxin

ARS scientists in Stoneville, Mississippi, are also using competitive exclusion to manage aflatoxin in corn. Their studies use a benign *Aspergillus* strain dubbed "K49" to outcompete the harmful fungi. In 4 years of field trials, K49 applications to corn reduced aflatoxin by 60 to 94 percent.

To understand how K49 colonizes corn kernels, ARS plant pathologist Hamed Abbas used the pin-bar inoculation technique of applying the treatment. In this method, small finishing nails embedded in a wooden dowel are dipped in a K49 spore suspension and then used to penetrate corn husks in order to inoculate the kernels inside with the beneficial strain.

"This benign *Aspergillus* culture reduces both the toxigenic species and the mycotoxins they produce, which is very exciting," says Abbas, who is in ARS's Crop Genetics Research Unit in Stoneville. A cooperative research and development agreement was established this year with industrial partners to develop the technology, and large-scale, multi-location field trials are in progress, he says. "We are developing novel formulations of K49 and Afla-Guard to make foliar and aerial application feasible in the future."

Other early research on competitive exclusion in cotton was done by ARS plant pathologist Peter Cotty, formerly in the ARS Food and Feed Safety Research Unit in New Orleans and now at the unit's Tucson, Arizona, worksite. In 1996, ARS was awarded EPA approval to test one *Aspergillus* formulation, named "AF36," in commercial cotton fields in Arizona. Successful testing paved the way for additional approvals and uses. EPA registration for use of AF36 on corn is pending.

Corn Germplasm Lines Resist Aflatoxin

"The presence of aflatoxin in corn grain greatly reduces its value and marketability," says ARS geneticist Paul Williams, who has worked on identifying and developing corn germplasm lines with genetic resistance to *A. flavus* infection and the subsequent accumulation of aflatoxin.

Corn, in particular, has been hit hard by aflatoxin, with annual losses to the corn industry estimated at $192 million.

Williams, who is in the ARS Corn Host Plant Resistance Research Unit (CHPRRU) at Mississippi State, leads a multidisciplinary research team of five ARS scientists located at Mississippi State University and works with other university and ARS collaborators from several states.

Williams and his scientific team have developed and released germplasm lines that exhibit the highest known levels of resistance to *A. flavus*. In field trials conducted in Mississippi in 2008 and 2009, mean aflatoxin accumulation was about 95 percent lower in the hybrids produced by crossing the ARS-developed germplasm lines than in a group of commercial hybrids adapted to Mississippi.

In the 2008 field trials, germplasm lines Mp715 and Mp717 exhibited the highest levels of resistance to aflatoxin contamination. In 2009 the recently developed germplasm line Mp04:097 performed well in the trials: Hybrids produced by crossing Mp04:097 with other resistant lines exhibited the lowest levels of aflatoxin accumulation.

Williams, geneticist Marilyn Warburton, and plant pathologist Gary Windham are also mapping quantitative trait loci (QTLs) associated with resistance to aflatoxin accumulation in crosses between resistant lines (Mp715 and Mp717) and susceptible lines with good agronomic qualities. Their goal is to identify linked markers that can be used in marker-assisted breeding. Geneticist Matthew Krakowsky, in the ARS Plant Science Research Unit, Raleigh, North Carolina, has cooperated in these investigations.

ARS researchers are working on different approaches to the problem of toxic *Aspergillus* fungi.

Williams says, "Aflatoxin accumulation is highly sensitive to environmental variations, and resistance is a highly quantitative trait, meaning that it's controlled by multiple genes. This makes breeding for resistance a challenge. We believe that molecular markers could be the key to the production of corn hybrids with resistance to aflatoxin accumulation."

The research team also found that the Mp715 and Mp717 lines are resistant not only to aflatoxin accumulation, but also to fumonisin accumulation. Fumonisin, like aflatoxin, is a mycotoxin—a toxic metabolite—and is produced by *F. verticillioides*. The toxin causes neurologic abnormalities in horses—such as weakness of the face and pharyngeal muscles, facial desensitization, and a tendency to lean to one side—after they've consumed infected corn.

"These lines should be useful in developing corn lines and hybrids with resistance to both fumonisin and aflatoxin accumulation in grain," says Williams. The lines have been widely requested and used in plant breeding programs in state, federal, and international research institutions plus three major commercial seed corn companies and several smaller companies.

The CHPRRU scientists have also developed and released corn germplasm lines with resistance to fall armyworm and southwestern corn borer, thus reducing the devastating leaf feeding by the two pests. Williams, along with CHPRRU agronomist Paul Buckley, tested 20 single-cross corn hybrids in laboratory bioassays: Larvae of both fall armyworm and southwestern corn borer weighed significantly less when fed the ARS-developed corn leaf tissue than when fed the susceptible hybrids. The CHPRRU scientists have demonstrated that growing hybrids that sustain less damage from such ear-feeding insects as fall armyworm, southwestern corn borer, and corn earworm results in reduced aflatoxin contamination.

In related research, by comparing aflatoxin-susceptible with aflatoxin-

STEPHEN AUSMUS (D1897-23)

In Stoneville, Mississippi, plant pathologist Hamed Abbas uses the pin-bar inoculation technique to evaluate the colonization of corn by the biological control agent K49.

STEPHEN AUSMUS (D1903-6)

In Starkville, Mississippi, geneticist Paul Williams places bags over the tassels of corn plants with the desired molecular markers to collect pollen.

STEPHEN AUSMUS (D1901-11)

At Starkville, molecular geneticist Marilyn Warburton harvests leaf matter for DNA genotyping. The goal is to identify plants with markers for resistance to *Aspergillus flavus* and aflatoxin accumulation.

STEPHEN AUSMUS (D1904-11)

To determine the resistance of corn lines to aflatoxin accumulation, plant pathologist Gary Windham injects *Aspergillus flavus* spores into corn ears grown in research plots at Starkville.

STEPHEN AUSMUS (D1896-6)

In Stoneville, Mississippi, biologist Bobbie Johnson adds ammonium hydroxide to *Aspergillus* cultures to differentiate aflatoxin-producing strains (yellow and red) from nonproducers (off-white).

STEPHEN AUSMUS (D1902-5)

Marilyn Warburton and geneticist Paul Williams tag corn plants identified in the lab as having molecular markers associated with resistance to *Aspergillus flavus* and aflatoxin accumulation. These tagged plants will be crossed with other breeding lines to develop resistant corn hybrids.

resistant corn lines (some developed by Williams), ARS plant pathologist Robert Brown in New Orleans identified and characterized a number of proteins that may be important in imparting resistance to corn. (See "Hardy New Corn Lines Resist Toxic Fungi," *Agricultural Research,* Oct. 2009, p. 14.) In the collaboration with Warburton mentioned above, the genes for these proteins have been mapped to chromosomal regions containing QTLs previously linked to aflatoxin resistance in the corn genome. These specific resistance-associated proteins can serve as targets for the marker-assisted breeding being carried out in Mississippi.

Expanding our horizons in corn breeding, Brown, with financial support from the USDA Foreign Agricultural Service, the United States Agency for International Development, and the ARS Office of International Programs, established a collaborative breeding program with the International Institute of Tropical Agriculture in Ibadan, Nigeria, which recently released six aflatoxin-resistant corn lines. These lines, the product of up to 10 generations of selection and inbreeding, have passed quarantine and are now available in the United States from the ARS North Central Regional Plant Introduction Station, Ames, Iowa.—By **Sharon Durham** and **Jan Suszkiw,** ARS, and **Alfredo Flores,** formerly with ARS.

This research is part of Food Safety (#108), Plant Genetic Resources, Genomics, and Genetic Improvement (#301), Plant Diseases (#303), and Crop Production (#305), four ARS national programs described at www.nps.ars.usda.gov.

To reach scientists mentioned in this story, contact Sharon Durham, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1611, sharon.durham@ars.usda.gov. ✻

Hops Could Reduce Ammonia Production in Cattle

KELLI GREENE (D1793-1)

Rumen microbiologist Michael Flythe (left) and technician Gloria Gellin prepare hops flowers for a bacterial growth inhibition experiment in an anaerobic glove chamber. HAB and other rumen bacteria are anaerobic, so all experiments must be performed in the absence of oxygen.

Nobody likes freeloaders, especially when they're wasting other people's money. That's why ARS microbiologist Michael Flythe is targeting a group of microscopic freeloaders that are racking up costs for cattle producers.

The culprits are naturally occurring bacteria that reside in the first of a ruminant's four stomach chambers, known as the "rumen." Unlike human stomachs, rumens contain symbiotic bacteria that enable grazing animals such as sheep, goats, deer, and cattle to digest grass and other fibrous plant matter.

"The rumen works just like an organization," Flythe says. "Some members work hard and get the job done and others just use up resources and don't contribute anything."

So who are the wastrels in this digestive scenario? A group of bacteria known collectively as "hyper-ammonia-producing bacteria," or HABs.

While other bacteria are efficiently converting plant material into cud, HABs break down amino acids, producing ammonia. This is problematic because cattle and other ruminants need amino acids to build muscle tissue. To compensate for the lost amino acids, producers have to add high-protein supplements to the feed, which is both expensive and inefficient.

Some ammonia is absorbed nutritionally, but most escapes the animal as urea. In terms of usefulness, ammonia production is sort of the ruminal equivalent of running a fantasy sports team from a work computer: It wastes time, energy, and resources without contributing much to the host organization.

At the ARS Forage Animal Production Research Unit (FAPRU) in Lexington, Kentucky, Flythe recently demonstrated that hops can reduce HAB populations. Hops, which were originally added to beer to inhibit growth of bacteria, are natural preservatives. But fermented beverages aren't the only media in which hops can slow bacterial growth, as this research demonstrates.

In the laboratory, Flythe introduced dried hops flowers and hops extracts to cultures of both pure HAB and a bacterial mix collected from a live cow's rumen. Both the flowers and the extracts inhibited HAB growth and ammonia production.

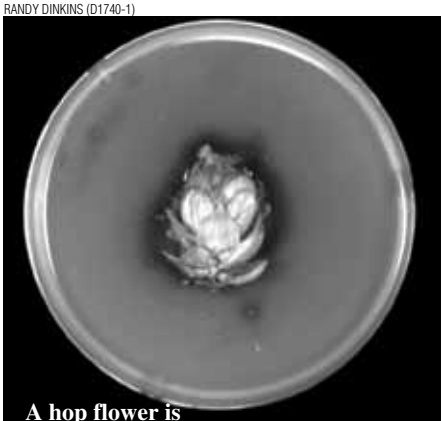
Flythe has not yet tested the effects on live cattle of introducing hops into their feed, but these preliminary results suggest that dietary hops, in addition to their well-documented antimicrobial benefits, could contribute to reduced ammonia production.

This work could have significant economic benefits for cattle producers, but further research is required to determine whether supplementing cattle feed with hops is entirely beneficial. After all, amino acid degradation is just one factor in the complicated process of rumen fermentation. Flythe plans to collaborate with FAPRU animal scientist Glen Aiken to evaluate the effect of hops on processes such as fiber digestion and acid formation.—By **Laura McGinnis,** formerly with ARS.

This research is part of Food Animal Production, an ARS national program (#101) described at www.nps.ars.usda.gov.

Michael Flythe is in the USDA-ARS Forage Animal Production Research Unit, Room N-220, Agricultural Science Building North, University of Kentucky, Lexington, KY 40546-0001; (859) 257-1647, michael.flythe@ars.usda.gov. ✸

RANDY DINKINS (D1740-1)



A hop flower is embedded in an agar plate that was inoculated with an HAB strain *(Clostridium sticklandii).* The opacity of the plate is caused by bacterial growth, and the dark halo around the flower is where the bacteria were inhibited by antimicrobial compounds in the plant.

Finding the Right Biofuels for the Southeast: A Range

Thanks to sunny skies and long growing seasons, farms and forests in the southeastern United States will play a major role in efforts to produce biomass for biofuels that reduce our nation's dependence on fossil fuels. And Agricultural Research Service scientists are focused on finding ways to tap into the region's potential.

Government mandates call for producing up to 36 billion gallons of biofuel to help meet the nation's transportation needs by 2022. While 15 billion gallons of that is expected to come from grain ethanol, the remaining 21 billion gallons will be derived from other feedstocks, such as sugarcane; perennial grasses, like switchgrass; and oilseed crops, such as rapeseed, pennycress, camelina, and soybean.

To achieve that goal, the U.S. Department of Agriculture has forged a number of strategic partnerships through its five USDA Regional Biomass Research Centers to coordinate research and tap into its nationwide resources and expertise. The centers are networks of scientists and facilities from two USDA agencies—ARS and the Forest Service Research and Development—in five regions across the United States: Central-East, Southeastern, Northern-East, Western, and Northwestern. (See related stories in this issue.) Of the five regions, the Southeast has the greatest natural capacity in the continental United States, with sufficient sunshine, soils, water, and other natural resources to produce more than 10 billion gallons of advanced biofuels each year, nearly a third of the 36 billion-gallon production target.

The goal for researchers is to develop high-yield bioenergy crops and production methods that minimize use of water and fertilizers and are compatible with current land uses. The systems have to be cost-effective for both growers and biofuel producers. Researchers also want to enhance environmental quality by increasing carbon sequestration and reduce the amount of nitrogen runoff to waterways.

"We need to understand all of the implications of helping this country meet its future energy needs by producing plants that will be viable sources of fuel. That means examining a number of issues, such as whether these crops can be produced on less productive lands in ways that preserve environmental quality," says William Anderson, an ARS geneticist in Tifton, Georgia, and co-coordinator of the Southeastern Regional Biomass Center.

ARS researchers working in Georgia, Louisiana, Nebraska, Hawaii, and elsewhere, with expertise in a wide range of scientific fields, are working toward developing a range of biomass crops for biofuels. They are finding that each crop offers a different set of challenges—and possible rewards. Work by Anderson and others, for instance, shows that napiergrass *(Pennisetum purpureum)* and varieties of sugarcane known as "energy cane" (*Saccharum* sp.) may work best in southern portions of Georgia and the rest of the region's southern tier. By comparison, switchgrass *(Panicum virgatum)*, a biomass crop being developed in the Midwest, is more cold tolerant than subtropical grasses and works better than energy cane in more northern areas of the Southeast.

Much of the USDA research effort in the South is focused on energy cane, napiergrass, and sweet sorghum *(Sorghum bicolor)*. With its expertise, extensive network of university and industry partners, and vast collections of plant material available for research, ARS is uniquely equipped to play a pivotal role in developing all three of these grasses into viable feedstocks for biofuels. ARS researchers are also working closely with companies that will produce biofuels so that they understand the companies' priorities and are using that insight in their efforts. It's an approach that is helping to accelerate progress toward lowering the potential costs of producing biofuels and making the biofuels price competitive with that of petroleum fuels.

Chopped up napiergrass from research plots. The material will be evaluated for moisture and ash content, as well as ability to be converted to renewable fuels.

PEGGY GREB (D2606-1)

The Sugarcane Connection

At the ARS Sugarcane Research Unit in Houma, Louisiana, and its field location in Canal Point, Florida, scientists are engaged in a program to supply growers and energy companies in the Gulf Coast and other southern states with new varieties of energy cane. Energy canes are derived by crossing cultivated sugarcane with related wild

# of Alternatives

grassy species that offer desirable traits for biofuel production. A key attribute from wild grasses is their high amount of stalk fiber, which has cellulose and other complex carbohydrates that can be converted into ethanol, complementing the ethanol that would be produced from the sugar.

Another desirable trait from wild grass species is cold tolerance, important to both energy cane and traditional forms of sugarcane. Incorporating this trait would not only extend the growing and milling season, but also enable production in states where sugarcane is not traditionally grown, such as Arkansas, Mississippi, Georgia, and the Carolinas. (Commercial sugar production on the U.S. mainland is currently limited to Louisiana, southern Florida, and Texas.)

"We don't anticipate any energy cane being grown in the traditional sugarcane growing areas of Florida, Louisiana, Texas, or Hawaii," says Ed Richard, who, prior to retiring in December 2011, led a 12-member energy cane research team at Houma. "We envision it being grown in the more northern zones of these states and in the other southern states, in rotations with pasture and other croplands that are not productive. In Hawaii, it may be grown on hilly land that is hard to irrigate," he says.

In Gulf Coast states like Louisiana and Florida, sugarcane is better suited to the region's soil types and subtropical climate. "A long growing season, abundance of land, and the availability of water make the Southeast ideal for the production of tall-growing herbaceous perennials," like sugarcane, sweet sorghum, and other related species, says Richard.

To date, the Houma group has released four energy cane varieties as part of a longstanding cooperative agreement with the Louisiana State University AgCenter and the American Sugar Cane League.

Napiergrass: Right for Some, Maybe Not For All

Napiergrass, also called "elephant grass," is a native of Africa and is used as cattle forage in much of the Tropics. Napiergrass offers advantages for the Southeast: It is drought tolerant and grows well on marginal lands and in riparian areas. It can also improve water quality in riparian areas by filtering out nutrients in runoff from row crop fields.

Both energy cane and napiergrass are subtropical grasses and are prime candidates for biomass production because they don't flower in most areas of the Southeast and continue to grow until the first frost.

In Tifton, Georgia, Anderson and colleagues compared napiergrass to energy cane, switchgrass, and giant reed *(Arundo donax)*. They grew the crops for 4 years and compared biomass yields and soil nutrient requirements. Joseph Knoll, a postdoctoral researcher in Anderson's laboratory in the ARS Crop Genetics and Breeding Research Unit in Tifton, led the research effort. The team also included Timothy Strickland and Robert Hubbard, ARS scientists with the Southeast Regional Watershed Research Unit in Tifton, and Ravindra Malik of Albany State University, Albany, Georgia. Results were published online in *BioEnergy Research* in 2012.

They found that energy cane and napiergrass are viable biofuel alternatives for growers in southern portions of Georgia and the rest of the region's southern tier, Anderson says. "Energy cane and napiergrass are not as cold tolerant as switchgrass, but they do offer advantages in areas where they can be produced, such as continued vegetative growth until killing frost," Anderson says.

Anderson and his colleagues are evaluating napiergrass with an eye toward improving yields, useable fiber content, and disease resistance. They are also testing different soil amendments, such as chicken litter, variable rates of inorganic fertilizer, and winter cover crops, and comparing those with no use of inputs.

"In one test, we're looking at six different rates of fertilizer use as well as different irrigation levels. We've also looked at the times of planting and harvest, comparing yields in areas where poultry litter was used and where synthetic fertilizer was used," Anderson says. Preliminary findings show that yields are sufficient without irrigation and that there is little difference

PEGGY GREB (K10668-1)

Technician David Verdun transplants energy cane seedlings into the field. In 2012, over 24,000 germplasm seedlings were transplanted. Several may prove to have potential for bioenergy use.

in yield when poultry litter is used instead of inorganic fertilizer.

Sorghum's Potential: How Sweet It Is

Sweet sorghum is a sturdy grass grown in the United States for livestock forage and for sugar for making syrup and molasses. But several attributes make it uniquely suited as a bioenergy crop in the Southeast. It is drought tolerant; adapts to diverse growing conditions; has low nitrogen fertilizer requirements; produces abundant biomass; can be rotated with cotton and peanuts; and is compatible with equipment used to harvest, transport, and mill sugarcane. It also contains soluble sugar that can be fermented directly into biofuel. The fiber (or bagasse) that remains after the sugar juice is extracted can be burned to generate electrical power—a strategy that South American sugarcane-producing countries are expanding.

"Sweet sorghum has the potential to augment biofuel and electricity production from cultivated sugarcane and lengthen the season for bioenergy production," says plant geneticist Jeff Pedersen, a former ARS scientist who was based in Lincoln, Nebraska, and collaborated on sweet sorghum studies for the Southeastern region before he retired in 2011.

In Tifton, Anderson and other researchers are trying to identify desirable sweet sorghum genes and understand their functions so they can improve on commercial varieties. The researchers selected 117 sweet sorghum genotypes from the ARS sorghum germplasm collection in Griffin, Georgia, where sorghum seeds from around the world are kept. (See sidebar at left.)

They tested the genotypes for 2 years, evaluating their ability to mature quickly and resist fall armyworm and anthracnose, a common fungal disease.

Sweet Sorghum Research: Building on the Past for a Better Future

Fuel-friendly varieties of sweet sorghum will need durable resistance to insect pests like fall armyworms and diseases such as maize dwarf mosaic. Breeders will also have to incorporate traits that prevent stalks from lodging, or toppling over, as they grow tall. Lodging is a problem because the crop will require mechanical harvesters. Fortunately, the Agricultural Research Service has a long history of sweet sorghum research and germplasm development dating back several decades. Its sizeable germplasm collection contains 2,163 accessions of sweet sorghum from around the world, which are maintained by Gary Pederson and colleagues at ARS's Plant Genetic Resources Conservation Unit in Griffin, Georgia. Among other projects, scientists there are assessing the sugar profiles of select sweet sorghum accessions and genetically characterizing them using DNA markers so that plant breeders can develop varieties suited for biofuel production.

Research leader Gary Pederson weighs sweet sorghum samples in the ARS collection maintained at the Plant Genetic Resources Conservation Unit in Griffin, Georgia.

Other ARS scientists are also conducting bioenergy research on sweet sorghum:

Molecular biologist Scott Sattler at Lincoln, Nebraska, is identifying genes, enzymes, and biochemical pathways involved in the crop's production of sucrose and other sugars. Ultimately, this will lead to new ways to ratchet up the activity of these genes or reengineer the pathways for even higher sugar yields than can be achieved with conventional plant-breeding methods.

In New Orleans, scientists Gillian Eggleston, Sarah Lingle (retired), and Maureen Wright at ARS's Southern Regional Research Center are focused on developing industrial process technologies to manufacture sweet sorghum syrup for year-round storage and transport and to maximize biofuel yields and other value-added biobased products, such as succinic acid. They are also determining whether starch, aconitic acid, and other impurities slow down fermentation and need to be removed to reduce the costs of production.

At Manhattan, Kansas, Scott Bean and colleagues at ARS's Grain Quality and Structure Research Unit are investigating the fermentation performance of "waxy" grain sorghum for ethanol production.—By **Jan Suszkiw,** ARS.

In Tifton, Georgia, geneticist Bill Anderson measures the h
practices for growing the crop on marginal soils.

PEGGY GREB (D2602-2)

The results are providing much-needed guidance to a growing biofuel industry, showing that sweet sorghum has tremendous potential as a biofuel crop for Southeast growers. The work also boosts efforts among breeders by identifying sorghum varieties that will make good candidates for developing future high seed-yielding hybrid varieties.

For all of sweet sorghum's bioenergy promise, there's still much work to be done, says Pedersen. In his estimation, sweet sorghum's long-term future as a bioenergy crop hinges on the ability of the seed industry to rapidly generate and deliver new elite hybrids—using dwarf seed-parent lines—that produce high yields of seed. Besides enabling laboratory and field research, having sufficient seed stocks "is going to be essential to getting the bioenergy industry going," says Pedersen.

The sweet sorghum improvement research work is one of several examples of work being done by researchers in Tifton to produce market-ready biofuel feedstocks. Environmental concerns are also a high priority being addressed by the Southeast Watershed Research Laboratory, in Tifton. "The lab is looking at potential effects on water quality, runoff, water-use efficiency, and carbon nitrogen pools in soils and plant tissue as biomass feedstock species are incorporated into Southeast agricultural systems," Anderson says.—By **Dennis O'Brien** and **Jan Suszkiw,** ARS.

To reach scientists mentioned in this article, contact Dennis O'Brien, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville MD 20705-5129; (301) 504-1624, dennis.obrien@ars.usda.gov.

The ARS locations included in this story are part of USDA's Regional Biomass Research Centers (RBRC) network. The RBRC is made up of five national centers whose mission is to help accelerate the establishment and production of sustainable commercial biomass from farms and forests without disrupting the production and marketing of food, feed, and fiber.

eight of energy cane in an experiment on production

PEGGY GREB (D2608-1)

Molecular biologist Scott Sattler places a pollination bag over the grain head of a hybrid plant that is a cross between a cultivated sorghum and a wild African sorghum bicolor species.

PEGGY GREB (K2609-1)

The Search for Nematode-Resistant Cotton

Agricultural Research Service scientists in Georgia and Mississippi are helping cotton growers deal with the double-barreled threat posed by two nematode species that lurk in their fields. The root-knot nematode *(Meloidogyne incognita)* thrives in the sandy soils throughout much of the southern United States and can cause crop losses of up to 10 percent worldwide. The reniform nematode *(Rotylenchulus reniformis)* is limited to warmer regions of the Cotton Belt, but its range is expanding. It causes an estimated $130 million in losses each year to the U.S. cotton industry. In some areas, crop losses caused by the reniform nematode are as high as 75 percent, depending on weather conditions. Losses are greatest under drought stress that typically occurs from midsummer to early fall.

Plant breeders have struggled to develop resistant lines in part because cotton has a diverse and complicated genome—some plants have two sets of chromosomes and some have four—making it difficult to cross "wild" resistant germplasm with commercial cultivars and come up with a hybrid that will produce seed. Developing lines resistant to root-knot nematode has been particularly challenging because resistance is a multi-gene trait, and that makes developing a resistant cultivar time consuming and extremely expensive.

ARS efforts have attracted support from cotton growers looking for environmentally friendly ways to repel soil pests. "Our best hope for future management of nematodes is to achieve through plant breeding much of what we are now doing with chemical treatments," says Robert Nichols, senior director for Cotton Incorporated, which is funding much of the work.

The research has taken on a sense of urgency because a pesticide widely used to control nematodes in cotton fields, Temik, is in short supply and is scheduled to be discontinued in the years ahead because of health and environmental concerns. The phase-out of the pesticide, also known as "aldicarb," is "prodding everyone working in this area to step lively," Nichols says.

Eliminating undesirable traits in cotton is a team effort in which researchers

Plant pathologist Sally Stetina (left) and technician Kristi Jordan examine cotton roots with a microscope to determine the level of infection by reniform nematode. By comparing infection levels in resistant test lines to those in susceptible controls, they can identify lines with the most resistance.

STEPHEN AUSMUS (D2513-2)

STEPHEN AUSMUS (D2511-15)

Geneticist John Erpelding cross-pollinates *Gossypium* cotton flowers to develop new populations.

essentially "pass the baton" to plant breeders to develop commercial varieties. Scientists use molecular tools to link nematode resistance with certain patterns in the plant's DNA, and those patterns are referred to as "markers." Researchers provide new cotton lines with those markers to plant breeders and they use them to screen for resistance based on the markers, crossing plants that have them with adapted commercial lines. This process eventually leads to lines with both resistance and the desirable traits inherited from commercial varieties.

ARS researchers are making it easier for breeders to develop commercially acceptable materials by transferring resistance genes from wild plants into cotton cultivars and releasing the resulting lines as breeding tools. They are also developing molecular markers to speed up identification of key nematode-resistance genes. Much of the research is focused on upland cotton *(Gossypium hirsutum),* which is native to Mexico and Central America and is one of two principal types of cotton, making up more than 95 percent of U.S. production.

"Finding genetic markers is critical if we want cotton breeders and private companies to get involved and begin developing commercial varieties with nematode resistance," says Richard Davis, an ARS plant pathologist at the Coastal Plain Experiment Station in Tifton, Georgia.

Davis and colleagues at the University of Georgia have released a root-knot-nematode-resistant line for breeders to work with, and they are hunting for additional genetic markers that will open pathways toward development of commercially viable resistant lines.

Davis has been focused on combating nematode resistance for years. In 2006 he and Peng Chee, his University of Georgia partner, published a paper that identified areas of the cotton genome where root-knot resistance genes are likely to reside. They have since refined the search by mapping portions of the chromosome where the resistance genes are located and identifying "flanking markers" that lie on either side of the genes themselves. These results, published in *Theoretical Applied Genetics,* will be critical in the search for the specific genes that confer resistance to nematodes.

Their new line is the result of several years of field trials where researchers evaluated crosses among cotton plants, some raised in fields inoculated with the nematode and others raised in fields free of it. The new line is susceptible to the reniform nematode and is not intended as a commercial cultivar. But it is an excellent tool for breeders and provides a source of resistance to root-knot nematode, along with yields higher than and quality superior to a breeding line released in 1989 and still used in many field trials as a research standard. Davis released the new line in a recent report in the *Journal of Plant Registrations*.

"What makes this release significant is that it has extremely good fiber quality, it resists the root-knot nematode, and it can grow all over the southeastern United States," Davis says.

Developing Cotton That Resists Both Nematodes

At the Crop Genetics Research Unit in Stoneville, Mississippi, ARS plant pathologist Sally Stetina and plant geneticist John Erpelding are conducting a program to insert genes for reniform nematode resistance into cultivated upland cotton varieties. Those resistance genes will come from several distant relatives: *G. aridum, G. arboreum, G. herbaceum,* and *G. barbadense.*

But crossing cultivated cotton with its distant cousins isn't easy, mainly because of chromosomal incompatibilities.

"Upland cotton is tetraploid—meaning it has four sets of chromosomes—and most of the related species with reniform nematode resistance are diploid, having two sets of chromosomes," explains Stetina.

Agronomist Jack McCarty (left) and geneticist Johnie Jenkins study one of the cotton lines that resist root-knot nematode. In ongoing studies, this resistant line is being crossed with other cotton plants to transfer resistance.

RUSS HAYES (D2518-1)

"When you cross these directly, you get a triploid hybrid, a plant with three sets of chromosomes that is sterile; it will not set seed, and the resistance you moved in will never be passed to the next generation."

The researchers' solution was to create an intermediary cotton strain, known as a "bridging line," using a series of complicated procedures, including embryo rescue and chromosome doubling. Its express purpose is to serve as a bridge between species so that genes for reniform nematode resistance can be passed from cotton's distant relatives into cultivated varieties or germplasm lines used to breed them. However, says Stetina, "When you bring in resistance from the related species, you can introduce undesirable traits such as smaller bolls, limited flowering, poor fiber quality, and poor performance under typical U.S. crop conditions. That's why additional crosses with adapted lines that have desirable agronomic traits are critical to getting the right combination of resistance and crop performance."

Markers provide an important tool to track resistance over multiple generations of crossing to ensure successful transfer, Erpelding adds.

Erpelding and Stetina aim to develop markers associated with reniform nematode resistance in *G. arboreum* and *G. herbaceum* and make them available to breeders. Markers are already available for reniform nematode resistance from *G. longicalyx, G. aridum,* and *G. barbadense* sources. These were developed by teams of researchers from ARS, Texas A&M University, Mississippi State University (MSU), Cotton Incorporated, and Monsanto Company, Stetina says.

Depending on the field in which it is grown, cotton can be attacked by many different nematodes, so varieties with resistance to two or more nematode species can be beneficial. In Mississippi, reniform nematode and root-knot nematode are the biggest challenges to profitable cotton production.

Stetina and Erpelding have teamed with MSU researchers Peggy Thaxton and Ted Wallace to develop cotton varieties with resistance to the two nematode species by using marker-assisted selection. Offspring from crosses are first selected based on the presence of markers for resistance. Plants that are found to have multiple sources of resistance are directly challenged with the nematodes to confirm the resistance. Advanced lines of upland cotton that resist one or both of the nematode pests may be ready for release in 2 to 4 years.

A Pest for the Past 100 Years

At the ARS Genetics and Precision Agricultural Research Unit in Mississippi State, Mississippi, geneticist Johnie Jenkins and his colleagues have also made significant strides in coming up with nematode-resistant cotton lines.

(D2549-1)

A juvenile root-knot nematode, *Meloidogyne incognita,* penetrates a tomato root. Once inside, the juvenile, which also attacks cotton roots, causes a gall to form and robs the plant of nutrients. Photo by William Wergin and Richard Sayre. Colorized by Stephen Ausmus.

Root-knot nematode has been recognized as a cotton pest for the past 100 years, according to Jenkins. "Since the 1930s, scientists have been looking for resistance to nematodes. In the 1960s, ARS started research in root-knot nematode resistance in cotton," says Jenkins. Raymond Shepherd, a retired ARS scientist, was instrumental in using root-knot nematode resistance in a line of wild cotton from Mexico to develop resistant germplasm, he says.

Jenkins and his colleagues found patterns of DNA associated with root-knot nematode resistance and key genetic underpinnings that confer resistance to reniform nematode. The markers they developed for resistance to root-knot nematode in upland cotton—found on chromosomes 11 and 14—should be useful in selecting plants with resistance. They also found that resistance to reniform nematode in a wild *G. barbadense* line is governed by more than one gene, and they have identified markers linked to these genes on chromosomes 21 and 18. They published separate articles on the root-knot nematode work and the reniform nematode work in *Theoretical and Applied Genetics.*

Commercial breeders had steered away from efforts to breed root-knot resistance into upland cotton lines over the years because it was governed by more than one gene and seemed so costly and time-consuming, says ARS agronomist Jack McCarty. But the research contributions from Jenkins and his colleagues may change that due to the use of marker-assisted selection.

"This research has sparked interest from some plant breeding companies in trying to develop high levels of resistance to root-knot and reniform nematode in upland cotton," he says.—By **Dennis O'Brien, Jan Suszkiw,** and **Sharon Durham,** ARS.

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

To reach scientists mentioned in this article, contact Dennis O'Brien, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1624, dennis.obrien@ars.usda.gov.

A Mississippi Graveyard

The Perfect Place for a Plant Mystery

Some plants stay put. Others wander all over the globe. And the journey of one restless plant—an Old World native that now thrives in several cemeteries in Meridian, Mississippi—could well be linked to the final resting places of several members of a royal Gypsy family.

Graveyards can be a good place to scout for plant species, which is what Mississippi State University graduate student Lucas Majure was doing in 2007 when he found an unknown sedge. He asked botanist Charles Bryson, who works at the Agricultural Research Service's Crop Production Systems Research Unit, in Stoneville, Mississippi, to help identify the mystery plant.

Bryson always keeps an eye out for the appearance of new and potentially invasive plants. After several months of searching, he was able to confirm that the plant was blue sedge *(Carex breviculmis),* a native of Asia and Australia and previously unknown from North America.

Bryson checked out three possible routes of introduction—planes, trains, and automobiles. He didn't find the sedge along highways or around military airfields in the area. He found it growing along the railroad tracks, but only around campgrounds used by vagrants and other transients. And he found it in or around four cemeteries in Meridian, including Rose Hill Cemetery, where the Queen of the Gypsies was buried in 1915. The King of the Gypsies was later buried alongside his queen, and the cemetery became a draw for visitors from all over the world.

Given the plant's restricted and distinctive distribution in the region, Bryson thinks that global travelers introduced the sedge into Mississippi, possibly via seeds trapped in clothing or by leaving plants or soil at the gravesites of the Gypsy royalty. Then cemetery caretakers may have spread plant material from the first introduction site to the other cemeteries via contaminated clothing and lawn care equipment.

Blue sedge is clearly a survivor, since it can even grow in sidewalk cracks. At two sites where it is established, it now exhibits "weedy" characteristics and reproduces and spreads profusely. Bryson collected leaf samples and preserved them in silica gel for DNA fingerprinting and is looking for a cooperator who can supply Old World leaf material for comparison. "With a diverse sample from the native range, fingerprinting could provide the origin of the introduction," he says.

Bryson and Majure published their findings in the *Journal of the Botanical Research Institute of Texas,* and Bryson is keeping an eye on the plant. "It's considered a weed in Asia, and I think it has the potential to become problematic in fruit and nut crops," Bryson says. "So we could be looking at another headache for the lawn and turf world."—By **Ann Perry,** ARS.

This research is part of Crop Protection and Quarantine (#304) and Crop Production (#305), two ARS national programs described at www.nps.ars.usda.gov.

Charles Bryson is in the USDA-ARS Crop Production Systems Research Unit, 141 Experiment Station Rd., Stoneville, MS 38776; (662) 686-5259, charles.bryson@ars.usda.gov.

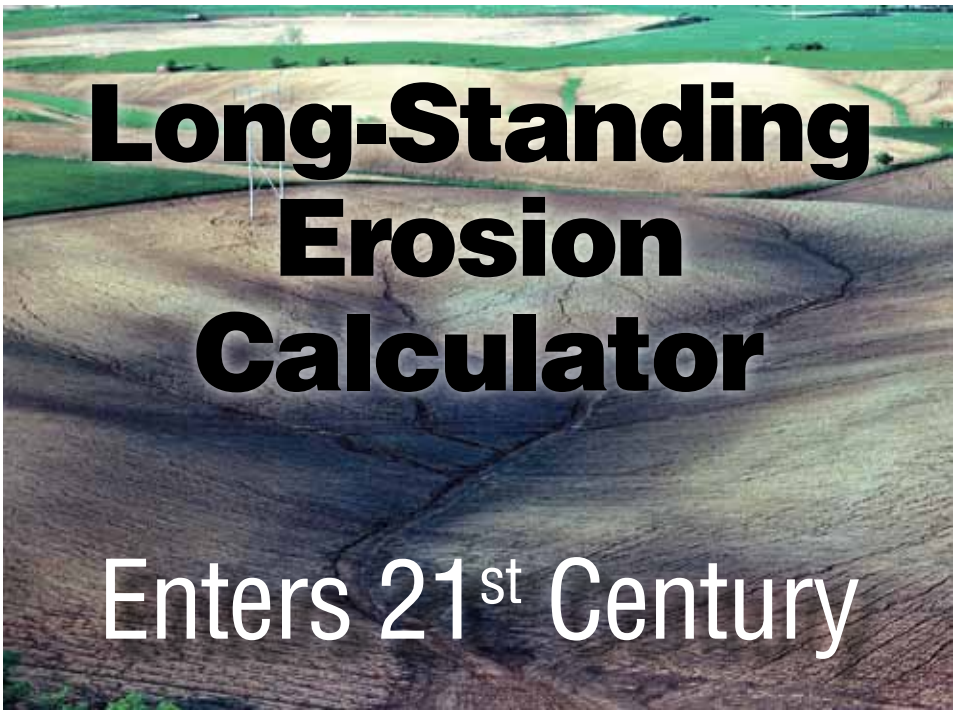
In Stoneville, Mississippi, botanist Charles Bryson uses a dissecting microscope and some herbarium specimens to identify the blue sedge, *Carex breviculmis,* discovered at a cemetery in Meridian, Mississippi.

STEPHEN AUSMUS (D2295-13)

CHARLES BRYSON (D2301-1)

Blue sedge, *Carex breviculmis,* near a tombstone at a cemetery in Meridian, Mississippi.

LYNN BETTS (NRCSIA99126)



Long-Standing Erosion Calculator Enters 21st Century

The core function of RUSLE2 is to estimate soil eroded by the impact of raindrops and by the flow of runoff water across land disturbed by plowing and tilling. Erosion caused by concentrated ephemeral gully flow in topographic swales is not currently included in RUSLE2 predictions but will be in the future.

Seth Dabney is busy tweaking a soon-to-be-unveiled update of the Revised Universal Soil Loss Equation, Version 2 (RUSLE2), which moves the original equation ever further from its origins in the age of slide rules to the era of computing.

Dabney is research leader of the Watershed Physical Processes Research Unit, at the Agricultural Research Service's National Sedimentation Laboratory in Oxford, Mississippi.

RUSLE2 has retained the integrity of the original Universal Soil Loss Equation (USLE)—in greatly expanded form—and integrated an updated database with a computer model that reflects both the latest in computer technology and scientific discoveries about erosion processes. It is unlikely that there is a more powerful, proven, practical computer model than RUSLE2. Its ability to predict daily erosion related to any human activity anywhere in the nation, based on a host of conditions, through a combination of simulation model, vast database, and scientific knowledge, makes it an excellent example of computational science and technology.

But RUSLE2 remains first and last what it was always designed to be: a management tool that allows conservationists to make better management decisions.

This state-of-the-art technology traces its heritage to the paper-and-pencil version of USLE, which has been the standard way to estimate soil erosion on farms for more than four decades. It was first developed in the late 1950s, before calculators, let alone computers. In fact, at one point the equation came with plastic slide rules custom made for it. The USLE is now recognized as one of the most significant developments in soil and water conservation history, worldwide.

Standing the Test of Time

The USLE began as a fairly simple equation that gave its answer in tons of soil lost per acre per year by multiplying five factors, with the numbers for each factor derived from paper tables of figures for different parts of the country and different soils. Proof of the worth of USLE's humble pencil-and-paper calculation is that it is still embedded as the heart—and anchor—of the new, sophisticated model that houses it, although the tables of factors no longer exist.

Its core function is to estimate soil eroded by the impact of raindrops and by the flow of runoff water across land disturbed by plowing and tilling. But functions have been added over the years, such as estimating how much plant residue can be removed from crop and pasture lands for ethanol production without exposing the soil to excessive erosion.

And the equation continues to add capabilities. It is now used to estimate erosion wherever land is disturbed, whether by farming or ranching, pasture replanting, or nonfarm activities such as construction, mining, or clearcutting and road building in forests.

Since the USLE moved into widespread use in the 1960s and 1970s, every conservation plan written for farmers, ranchers, and others by the USDA Natural Resources Conservation Service (NRCS) has been based on soil-erosion calculations derived from this equation. It is used by all 3,000 NRCS field offices as well as the agency's state and area offices.

Ken Renard, a hydraulic engineer who came to ARS in 1957 and has been a leader in the development of the USLE and RUSLE even in retirement, says that as "research made a lot of progress in more realistically describing erosion from farming operations," the need to update USLE technology became clear.

Computational Tech

The result was RUSLE1, which started moving into use in 1992; it was the first wholesale reworking of the erosion-predicting technique using digital computer technology.

The Improvements Continue

Spearheaded by now-retired ARS agricultural engineer George Foster, RUSLE2 is actually a combination of observation- and process-based science, incorporating its original roots in collected field data with the latest in computer models that can simulate processes such as erosion, says Giulio Ferruzzi, a conservation agronomist at the NRCS West National Technology Support Center in Portland, Oregon. Ferruzzi forwards all of the agency's requests for changes to the RUSLE2 to Dabney and Daniel Yoder, a professor at the University of Tennessee at Knoxville.

At the time RUSLE1 moved into use, the task of improving its computer programs fell to Yoder, who, while a graduate student, worked for ARS as an agricultural engineer at the National Soil Erosion Laboratory in West Lafayette, Indiana, at Purdue University, the birthplace of the equation.

Now, 20 years later, Yoder is still improving the RUSLE2 version, first developed in 2001. RUSLE2 brought the equation into the 21st century, making it a much more powerful tool, yet much more user-friendly, with graphics, including icons for things like bulldozers and tractors.

Yoder says, "I take Dabney's science ideas and translate them into computer code. But the process is give-and-take between me, Dabney and his ARS colleagues, and NRCS." He says their recent work on improvements to RUSLE2 involved better prediction of crop residue.

Ferruzzi adds that Dabney for the first time made it possible for NRCS to help ranchers more accurately learn the effects of cattle grazing on erosion. The update about to be unveiled simulates the natural life and death of pasture plants as well as the effects of the different eating habits of grazing animals. Ferruzzi explains that when cows are let into a pasture for a short time, they tend to eat everything in sight by "mob grazing." But when cows are put in a pasture for a season, they have time to be more selective, eating only the freshest growth. The model Dabney is working on takes that into account.

A New Way To View Erosion: But Ephemeral Gullies Still Elude

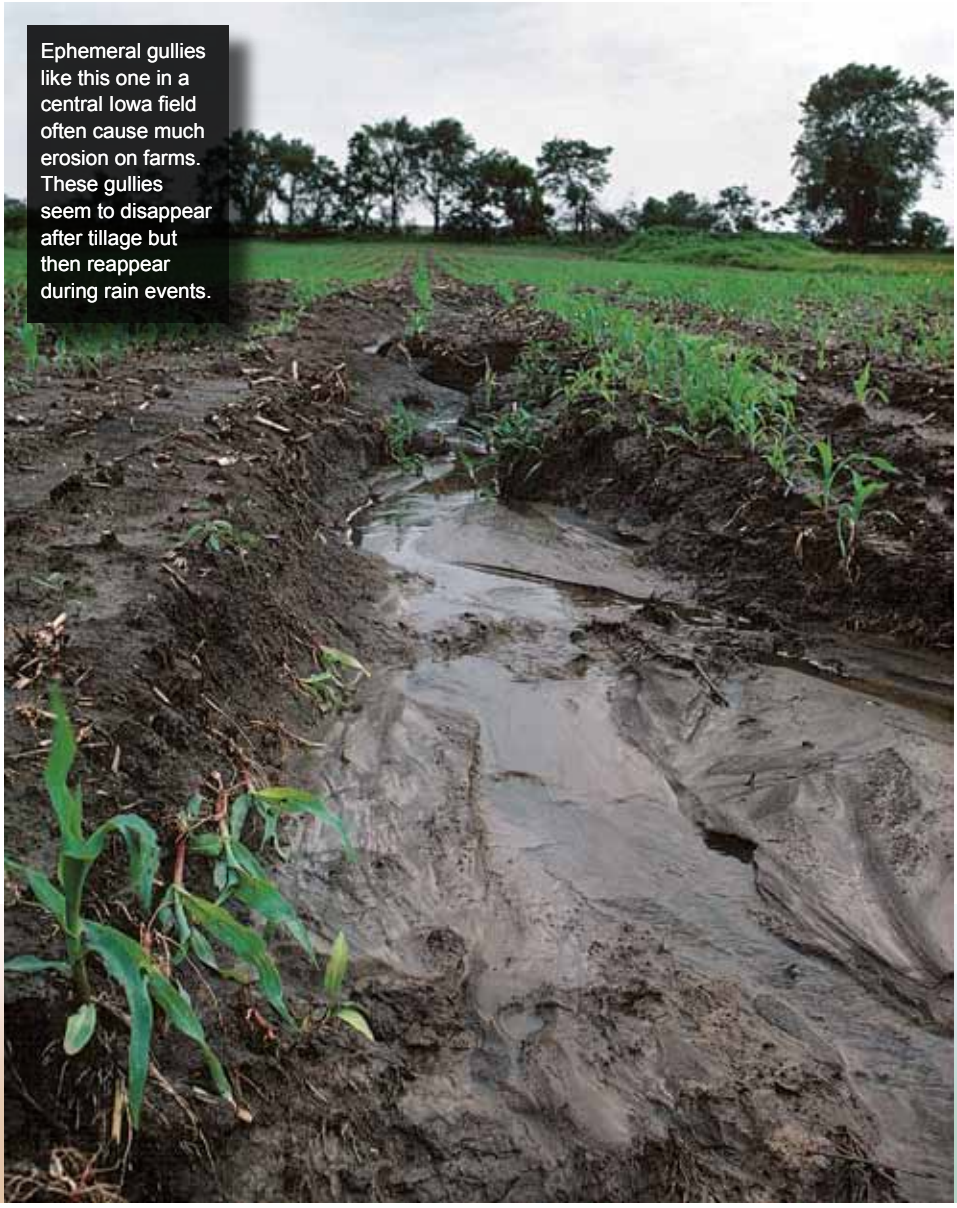
Dabney also added a way to model the erosive flow of water on an entire hill slope as one block, from top to bottom, missing—for now—only the topographic swales where water runs intermittently when it rains heavily and forms ephemeral gullies. The current version also predicts where the eroded soil will collect after it leaves the hillside, something particularly important to construction planners.

Renard says that ephemeral gullies often cause the most erosion on farms. They're particularly insidious because they are obliterated by tillage, but reappear during a wet spell the next season. Renard says that although RUSLE2 is still missing these gullies, Dabney is moving in the direction of solving that.

Ferruzzi says NRCS can use this new modeling technique to pinpoint where permanent gullies might form and suggest grassed waterways or other conservation measures there to prevent gully formation.

A Crown Jewel

Yoder calls the extensive NRCS database a "crown jewel of RUSLE2." Federally supported data collection began with 10 experiment stations in 1929, located strategically to represent as many crops and climate and management conditions as possible. NRCS has since built it up to include every state in the nation plus the territory of Puerto Rico and the Pacific protectorates.



Ephemeral gullies like this one in a central Iowa field often cause much erosion on farms. These gullies seem to disappear after tillage but then reappear during rain events.

LYNN BETTS (NRCSIA99140)

ARS NATIONAL SEDIMENTATION LABORATORY (D2464-1)

Spearheaded by now-retired ARS engineer George Foster, seen here in the late 1960s or early 1970s, RUSLE2 is a combination of observation- and process-based science, incorporating its original roots in extensive field data into a state-of-the-art computer-based conservation tool.

Dabney agrees, saying that the NRCS database is exhaustive, with 30,000 combinations of vegetation, farming and ranching operations, and residue types. "NRCS developed this database at regional centers in Nebraska, Oregon, South Carolina, and Texas, and it has been in use for 10 years now," Dabney says. NRCS has also developed maps for RUSLE2 that divide the country into crop management zones. The maps disregard political boundaries, instead delineating zones based on common crops and management practices.

Dabney says that it is this very database that keeps RUSLE2 from coming untethered from reality, as pure process models do when they operate outside of known territory. RUSLE2 can operate accurately anywhere in the United States—and probably the world—because it is grounded by the vast database collected from field measurements.

Dave Lightle, former NRCS national database manager for RUSLE2, worked for 10 years to produce the database, with the different combinations of management scenarios broken down by the crop management zones. The scenarios replace USLE's key crop management factor. "RUSLE2 now creates these scenarios. It goes way beyond USLE and RUSLE1," says Lightle, who continues to work part-time on RUSLE2 in retirement. Linda Scheffe, at the NRCS National Soil Survey Center in Lincoln, Nebraska, is the current RUSLE2 database manager.

RUSLE2 can operate accurately anywhere in the United States—and probably the world—because it is grounded by the vast database collected from field measurements.

The database contains 20 key soil properties that affect soil erosion for all soils in the United States. It also contains the climate for all counties, the precipitation ranges across the country, and hundreds of tillage options. RUSLE2 provides daily information, unlike USLE, which provided information on a yearly basis.

Lightle says that this database is the most sought-after feature of RUSLE and is being used in other models. Currently, users have to download soil data from the NRCS National Soil Information System, the agency's official soil database. But Lightle says that in the near future RUSLE2 will be live on the Internet, enabling access to that data without downloading.—By **Don Comis,** formerly with ARS.

This research is part of Climate Change, Soils, and Emissions (#212) and Water Availability and Watershed Management (#211), two ARS national programs described at www.nps.ars.usda.gov.

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

ARS Assists in Fight Against Kudzu Bug

Don't let its common name fool you: The kudzu bug is not your friend.

RICHARD EVANS (D2500-1)

Adult kudzu bug, *Megacopta cribraria*.

Sure, this distant relative of the brown marmorated stink bug will feed voraciously on the stems of kudzu, the "Vine That Ate the South." But *Megacopta cribraria* also has a taste for soybean and other legumes. In Georgia, where this native of Asia was first discovered in the United States in October 2009, there's worry that the pest will set its sights on peanut, endangering a $2 billion crop that supplies nearly 50 percent of America's peanuts (Georgia Peanut Commission, 2009).

Like the brown marmorated stink bug, *Megacopta*—also known as the "bean plataspid"—seeks shelter inside homes, buildings, and vehicles during the fall as temperatures cool. And when disturbed, it too emits a foul smell.

Researchers, however, haven't been idle. For example, at the Agricultural Research Service's Stoneville [Mississippi] Quarantine Research Facility, entomologist Walker Jones is evaluating a secret weapon in the form of *Paratelenomus saccharalis,* a tiny black wasp received, under permit, from Japan in 2011.

Though nonstinging and harmless to humans, pets, and other animals, *P. saccharalis* is a top natural enemy of *Megacopta* in Japan. More specifically, the wasp lays its eggs in the bug's eggs. Upon hatching, the wasp's maggotlike brood devour the bug's own developing embryos, reducing the size of the next generation.

In North America, there are no specific natural enemies to keep the pest's numbers in check—hence the interest in *P. saccharalis* for potential use in biocontrol programs. But first, the wasp must pass muster on a long list of requirements assuring its host specificity and environmental safety—starting with quarantine trials at Stoneville.

Megacopta belongs to an insect family that doesn't occur naturally anywhere in the Americas. Thus, importing its coevolved natural enemies isn't expected to endanger native U.S. bug species. If research bears this out, getting permission to release a promising host-specific natural enemy like *P. saccharalis* will be facilitated. Its successful establishment would not only reduce crop damage, but also curb the rate and intensity of *Megacopta's* spread.

"I am presently screening eggs of native species of related bugs to see if it will attack them, and so far, it doesn't look like it will," reports Jones, who leads ARS's Biological Control of Pests Research Unit in Stoneville. He's conducting the evaluations using a steady supply of bugs, representing 4 families and 15 species, sent by colleagues from ARS, private industry, and universities, including the University of Georgia and Clemson University.

Cooperators in Asia and at ARS's European Biological Control Laboratory in Montpellier, France, are also searching for natural enemies.

On a related front, Jones's lab has devised a procedure for freezing *Megacopta* eggs and thawing them as needed, which will help with timing the mass production and release of the wasps.

Besides the wasp evaluations, this effort includes tracking *Megacopta* (it has spread to Alabama, North Carolina, South Carolina, Tennessee, and Virginia) and genetic fingerprinting. Using this sophisticated procedure, U.S. scientists recently matched DNA from Georgia's *Megacopta* population to indigenous populations of the bug in Japan, a finding that should help them discover how the pest arrived in the United States.

Meanwhile, more is being learned about *Megacopta's* basic biology, host-crop range, economic impact, chemical control, and vulnerability to native predators, parasites, or pathogens. Researchers want to provide farmers with an arsenal of weaponry to choose from. It may be a few years before egg-parasitizing wasps are patrolling crop fields, but chances are the bug will still be around.—By **Jan Suszkiw,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

Walker Jones is in the USDA-ARS Biological Control of Pests Research Unit, 59 Lee Road, Stoneville, MS 38776; (662) 686-5229, walker.jones@ars.usda.gov.

(D2467-1)

Cotton Gets Nanotech and Biotech Treatment in New Orleans

Scientists at the Agricultural Research Service's Cotton Chemistry and Utilization Research Unit (CCUR) in New Orleans, Louisiana, have a long history of research successes leading to advances in the use, manufacturing, and quality of cotton fiber.

For example, groundbreaking studies led by chemist Ruth Benerito at the Cotton Chemical Reactions Laboratory (CCUR's predecessor), starting in the 1950s, gave rise to easy-care, permanent-press clothing and other consumer-friendly improvements that helped cotton better compete with synthetic fibers, like polyester and nylon.

New challenges and consumer demands have since emerged, but the ARS lab's tradition of excellence and innovation in research continues.

Under the leadership of Brian Condon, CCUR researchers today are leveraging the latest developments in nanotechnology to bring cotton into the 21st century. Foreseeable applications range from the purely functional—like better shrink resistance—to the truly futuristic, such as fabrics made of cotton-optical fiber blends that can change color.

Flame-Retardant Coating

In one ongoing project, Condon and CCUR chemist SeChin Chang are collaborating with Texas A&M University (TAMU) scientists to evaluate a first-of-its-kind, environmentally friendly flame retardant for cotton apparel and durable goods.

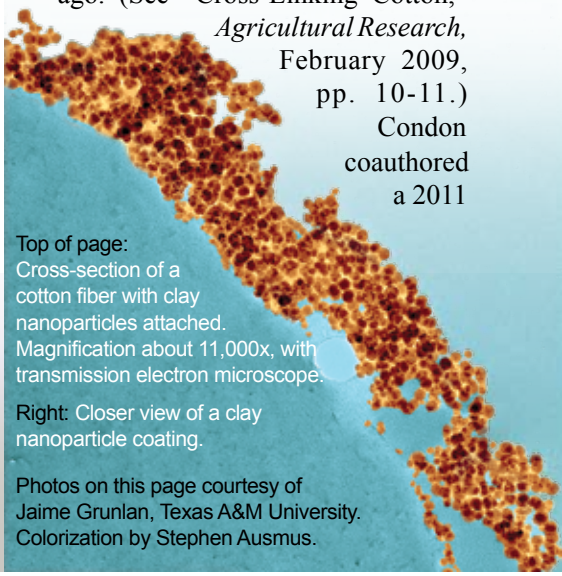
Halogenated flame retardants have been among the most widely used chemical treatments for cotton. But there's been a push to find alternatives that are not only more benign, but that also avoid imparting the same stiffness to fabric characteristic of some chemical treatments. For these and other reasons, "the textiles industry would like to move away from using halogenated flame retardants," says Condon.

Made of water-soluble polymers, nanoscale clay particles, and other "green" ingredients, the ARS-TAMU flame retardant is applied as a nanocoating that reacts to open flame by rapidly forming a swollen, charred surface layer. This process, known as "intumescence," stops the flame from reaching underlying or adjacent fibers.

A team led by Jaime Grunlan at TAMU's Department of Mechanical Engineering, in College Station, Texas, originally developed the intumescent nanocoating using a layer-by-layer assembly. In this procedure, alternating layers of positively and negatively charged ingredients, including clay particles 50-100 nanometers wide, are deposited onto the surface of a desired material. The result is a striated nanocoating that, when viewed under a scanning electron or other high-powered microscope, resembles the stacked layers of a brick wall.

Condon's interest was piqued after listening to Grunlan discuss his team's research at a recent American Chemical Society meeting, and he approached the TAMU professor about potential benefits to cotton. That conversation, in turn, led to a cooperative research project enabling Condon and Chang to evaluate the nanocoating at CCUR.

Treating cotton for flame resistance isn't a recent concept, adds Condon, whose lab is part of the ARS Southern Regional Research Center in New Orleans. In fact, some of the most successful early treatments were born of research conducted by Benerito and colleagues there several decades ago. (See "Cross-Linking Cotton," *Agricultural Research,* February 2009, pp. 10-11.) Condon coauthored a 2011



Top of page: Cross-section of a cotton fiber with clay nanoparticles attached. Magnification about 11,000x, with transmission electron microscope.

Right: Closer view of a clay nanoparticle coating.

Photos on this page courtesy of Jaime Grunlan, Texas A&M University. Colorization by Stephen Ausmus.

(D2466-1)

Nanotech

ACS Nano paper on the potential of intumescent coatings together with Chang, Grunlan and his TAMU team, and Alexander Morgan of the University of Dayton Research Institute in Ohio.

Early trials of the nanocoating using standard flame-resistance tests are promising. In one case, 95 percent of treated cotton fabric remained intact after exposure to flame, whereas the untreated fabric used for comparison was completely destroyed

"What we're investigating now is how well it will perform after repeated launderings of treated fabric," says Condon. "After all, the coating contains clay, and that's something detergents are made to remove."

Even if the coating does eventually wash out and the treated fabric loses its flame resistance, the nanotech approach could still be used to protect textiles and durable goods that aren't frequently washed, such as upholstery, mattress pads, box spring covers, automotive interiors, and firefighter coats.

Tapping Silver's Antimicrobial Properties

On another nanotech front, Condon and CCUR engineer Sunghyun Nam are investigating a way to inhibit microbial growth in cotton using silver particles ranging in size from about 2 to 6 nanometers. Silver nanoparticles have been used as an antimicrobial agent in many products, including clothes, plastic food containers, and medical textiles. The methods of producing them, however, have mostly relied on the use of toxic agents and organic solvents.

Condon's team has explored an alternative approach using an environmentally friendly agent, polyethylene glycol, and water as a solvent to generate silver nanoparticles of the desired size. Condon and Nam reported on this method in the *Journal of Nanoparticle Research* together with engineer Dharnidhar Parikh, formerly with CCUR. Also under investigation is a new method by which the nanoparticles form directly on cotton fiber, eliminating handling and storage of the particles before application. "This is a leg up for cotton over the synthetics," which have not been amenable to silver nanoparticle treatment, says Condon.

From Nanotech to Biotech

The CCUR scientists have also been busy on the biotech front.

In one project, CCUR chemist Vince Edwards, together with Condon, devised a treatment for impregnating nonwoven cotton fabrics with lysozyme, an enzyme that slices open the cell walls of microorganisms, killing them—including microbes that cause infection or odor. That same cell-slicing capacity may also be used for biodefense applications that deactivate nerve agents—essentially by chewing them up, or "hydrolyzing" them, he adds. By adding the lysozyme to cottons, the resulting nonwovens could have these bactericidal and detoxifying properties.

In another biotech project, Condon and CCUR chemist Michael Easson are experimenting with equipment that generates an ultrasonic field of mechanical energy (similar to that used to clean jewelry) to improve the biobased processing of raw, or "greige," cotton using enzymes, like cellulase. Chemical processing agents are now used to strip away waxes, pectins, fats, and other fiber components that can hinder subsequent dying procedures and diminish the quality of finished cotton products. But the waste these "wet chemistry" methods generate is a concern.

"We're interested in enzymes as an environmentally friendly alternative, and we found that subjecting a solution of the enzymes to a field of ultrasonic energy can speed up their reaction rates," says Condon.

In experiments with lint fibers, for example, use of ultrasonic energy increased the bioprocessing efficiency of cellulase by 22 percent. The same concept can also work to improve the conversion of cotton sugars into biofuels—a potential value-added market for 2 million tons of U.S. cotton gin waste generated annually.

Chemist Sunghyun Nam examines suspensions of silver nanoparticles. Fabrics can be treated with these nanoparticles to add antimicrobial qualities.

Besides publishing their findings in scientific journals, Condon's team is actively seeking commercial partners to help usher these advances into the marketplace—all with an eye towards assuring the viability of America's $25 billion cotton industry at a time of increasing production costs, dwindling resources, and global competition.—By **Jan Suszkiw,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS national program (#306) described at www.nps.ars.usda.gov.

Brian Condon is in the USDA-ARS Cotton Chemistry Research Unit, Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124; (504) 286-4540, brian.condon@ars.usda.gov.

Following flame exposure, the untreated fabric (top) is completely destroyed, but the fabric treated with clay nanoparticles is intact.

SeCHIN CHANG (D2465-1)

Biotech

Roundworms (and Their Bacterial Buddies) Rub Out Pests

Roundworms, microscopic wormlike organisms also known as "nematodes," can be friend, foe, or something in between. Some species are parasitic, dependent on hosts—plant, animal, insect, or human—to survive. Others are stealthy predators, prowling soils and other hunting grounds for bacteria, fungi, and other microbial prey—or sometimes ambushing them.

Lynn Carta and colleagues at the Agricultural Research Service's Nematology Laboratory in Beltsville, Maryland, are among the world's foremost authorities on nematodes and have developed sophisticated tools and techniques for studying their morphological, biochemical, and genetic features in unprecedented detail.

Not surprisingly, the lab's services are in high demand, especially from regulatory agencies tasked with safeguarding U.S. agriculture from the entry of exotic pathogens and pests, such as the pale cyst nematode, *Globodera pallida,* which damages potato, tomato, and other crops.

The ARS lab's expertise is also critical to research aimed at harnessing beneficial species of insect-killing (entomopathogenic) nematodes as biocontrol agents, which can be commercially formulated as an alternative to synthetic pesticides.

Casting About for New Talent

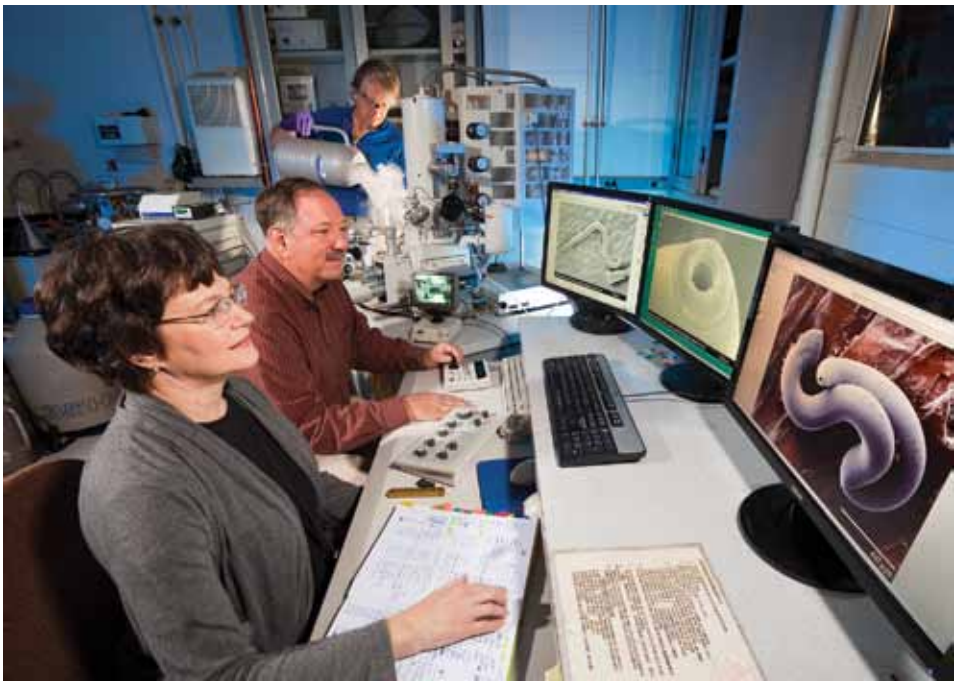
Lately, Carta has focused attention on identifying and describing nematodes that have potential as biological controls for Formosan subterranean termites, a nonnative species whose appetite for cellulose—whether it be the heartwood of trees or the wooden support beams of buildings—causes an estimated $1 billion annually in damages, repairs, and controls.

Since 1999, Carta has determined the identities of seven nematode species isolated from the bodies of Formosan termites by Ashok Raina, a retired entomologist formerly with ARS's Southern Regional Research Center in New Orleans, Louisiana. Other specimens Carta has identified were collected from more exotic locales, including rural sites in Uzbekistan, where collaborators found species of *Pelodera* nematodes in the heads, abdomens, and legs of dead or sick Turkestan termites. The team reported its findings in the December 2010 issue of the *International Journal of Nematology.*

"Common entomopathogenic nematodes don't kill invasive Formosan termites efficiently," notes Carta. Thus, more virulent species are sought, and so are symbiotic microorganisms, such as bacteria, that can assist in killing the termites or other insect hosts. The *Pelodera* nematodes are of interest "because of their association with significant sickness and mortality in termites in Uzbekistan," she says.

A *Poikilolaimus* nematode species that Raina collected in Louisiana is also of in

Plant pathologist Lynn Carta (left) and Gary Bauchan (center), director of the Electron and Confocal Microscopy Unit, use a low-temperature scanning electron microscope to view nematode anatomical structures useful for species identification. In the background, support scientist Charlie Murphy adds liquid nitrogen, which is used to preserve the specimens at very cold temperatures.



STEPHEN AUSMUS (D2540-6)

Mouth parts of a *Parasitorhabditis frontali* nematode. Image courtesy of Lynn Carta and Gary Bauchan; colorization by Stephen Ausmus.

(D2547-1)

terest. His early experiments showed that this nematode species invades the heads of Formosan termites and that a bacterial accomplice probably sickened the insects in the field. The bacteria, which were identified by ARS microbiologist Phyllis Martin, are known to excrete trace amounts of cyanide. But whether this played a role in the termite's deaths has yet to be determined. "We did not identify the bacterium from the termite itself, but only found it with the nematode," says Carta.

Still, the bacterial association raises an interesting prospect: using nematodes as vectors of insect pathogens rather than as primary biocontrol agents—the traditional approach. Applied to the soil, for example, the nematodes would find, penetrate, and then infest their targeted insect hosts with lethal doses of entomopathogenic bacteria.

Setting the Stage

That such approaches can even be considered is a credit to the wealth of information resulting from studies by Carta and colleagues. This includes meticulous drawings that identify parts of nematodes—including their mouth and tail features—determinations of their host range and nature of their associations, geographic distribution, taxonomic groupings, genetic sequences, and other data.

It also helps to have high-tech tools handy, including a scanning electron microscope (SEM), which uses special sensors and an electron beam to produce images of specimens that far surpass what can be achieved with standard light microscopes. Eric Erbe and William Wergin, both retired and formerly with ARS's Electron and Confocal Microscopy Unit (ECMU) in Beltsville, Maryland, are among those Carta credits with assisting in her investigations. She also credits Gary Bauchan, who now directs research at ECMU.

Carta's recent SEM-aided collaborations include working with a team of researchers led by Cetin Yuceer from Mississippi State University and including scientists from the University of Chicago, Davidson College, Hendrix College, and the USDA Forest Service to identify a new nematode species that's associated with the southern pine beetle, *Dendroctonus frontalis.*

The 1/8-inch-long beetle is a pest of coniferous forests mainly in the southeastern United States. Outbreaks are sporadic, but can be costly. For example, an outbreak from 1992 to 1993 on nearly 3,000 acres in Maryland destroyed 20 million board feet of loblolly pine, according to the state's Department of Natural Resources.

The researchers' studies suggest the nematode is a new species of *Parasitorhabditis*—similar to those found infesting beetles in parts of Texas, New York, and Germany. Besides its taxonomic significance, the nematode's discovery may shed further light on the pest's ecological role and success, as well as expose vulnerabilities that could be exploited.

Oh, What a Tangled Web…

Carta's sleuthing has also helped finger a nematode-microbe duo in the deaths of pet tarantulas. The nematode, a *Panagrellus* species, apparently harms the spider only in captivity. The nematode is suspected of being present in some insects fed to tarantulas, including mealworms, the larval stage of a bark beetle. Once inside the tarantula's mouth, the nematode wriggles into the spider's head, feeding on its brain and eventually killing it. Carta believes a yeast is also involved. She is intrigued by the possibility, because it would reveal a new ecological association that could yield novel approaches to pest control.

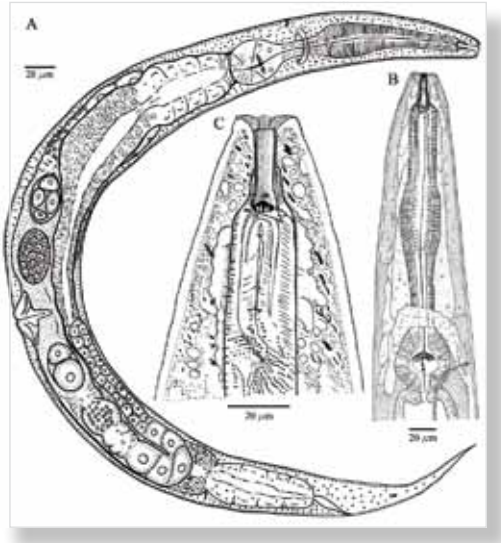
On another front, nematology research like Carta's may have direct bearing on the well-being of soils and plants. Applying commercially formulated bacteria to kill root-damaging nematodes or fungi, for example, can also harm nontarget species that help with nutrient recycling. Conversely, species of bacteria-feeding nematodes that occur in soils may prey on commercially formulated bacteria that have been applied, possibly reducing *their* biocontrol effectiveness.

The subterranean world in which nematodes operate is complex and interwoven. Knowledge gained from studies by Carta and others is improving our understanding—as well as use, management, and appreciation of—these ubiquitous organisms.—By **Jan Suszkiw,** ARS.

This research is part of Plant Diseases, an ARS national program (#303) described at www.nps.ars.usda.gov.

Lynn Carta is with the USDA-ARS Nematology Laboratory, 10300 Baltimore Ave., Bldg. 010A, Room 110, Beltsville, MD 20705-2350; (301) 504-8787, lynn.carta@ars.usda.gov.

Meticulous drawings such as this one by Lynn Carta were used to describe *Rhabditis (Metarhabditis) rainai.*



LYNN CARTA (D2541-1)

Rhabditis (Metarhabditis) rainai, a potential biocontrol agent against Formosan termites.

LYNN CARTA (D2546-1)

A Formosan subterranean termite soldier.

SCOTT BAUER (K8085-3)

Beneficial Fungus Formulated Into

Aflatoxins are highly toxic substances produced by several species of *Aspergillus* fungi. But not all *Aspergillus* produce aflatoxins. Some, in fact, are considered beneficial. One such strain, K49, is now being recruited to battle its harmful *Aspergillus* relatives, preventing them from contaminating host crops, like corn, with the carcinogen.

In collaboration with Italy's University of Bologna (UB) microbiologist Cesare Accinelli, ARS plant pathologist Hamed Abbas and ARS soil microbiologist Bob Zablotowicz (now retired) devised a new method of formulating K49 as a first-line defense against aflatoxin contamination of corn, which costs an estimated $200 million annually in U.S. losses alone. So potent is the aflatoxin that U.S. law prohibits the sale of corn or any grain destined for human consumption if it contains more than 20 parts per billion.

K49 is known as nontoxigenic (or atoxigenic) because of its inability to produce aflatoxin, explains Abbas, who is with ARS's Biological Control of Pests Research Unit in Stoneville, Mississippi. But the fungus, or mold, is quite adept at excluding its toxin-producing cousins (*A. flavus* and *A. parasiticus*) from ecological niches and resources that both need to survive. Exploiting this rivalry, called "biocompetitive exclusion," offers an effective way to diminish aflatoxin levels in both soil and corn kernels, says Abbas, who coauthored a 2011 *Crop Protection* paper with Accinelli and his colleagues at UB's Department of Agro-Environmental Science and Technology in Bologna, Italy.

Wheat and barley grains are typically used as carriers to apply commercial strains of biocompetitive *Aspergillus* molds. But instead of using those grains, the ARS-UB team encapsulated K49 in a bioplastic product, called "Mater-Bi," made of cornstarch, vegetable oil, and other constituents.

These bullet-shaped granules in which K49 is encapsulated offer several advantages, says Abbas. Chief among these is improved storage life and viability of the mold, once applied. The formulation's starch component also provides nourishment to the mold. And because actual wheat and barley grains aren't used, seed-hungry animals like rats and birds aren't likely to eat the formulation, giving K49 a chance to release spores for dispersal to corn plants via wind or insect feeding. The bioplastic is also a readily available resource that

PEGGY GREB (D2671-1)

Plant pathologist Hamed Abbas applies the nontoxigenic *Aspergillus flavus* formulated in bioplastic granules to knee-high corn.

PEGGY GREB (D2673-1)

Following application, some of the nontoxigenic *A. flavus* bioplastic granules end up between the leaves of the developing corn plant. Most of the granules fall to the ground.

Bioplastic "Bullets"

PEGGY GREB (D2674-1)

Hamed Abbas and technician Caleb Chambers prepare bioplastic granules for field trials to control aflatoxin in corn.

biopesticide makers can use, and it safely degrades in the environment, Abbas notes.

During field tests in the Mississippi Delta from 2001 to 2004, inoculation of grains with K49 dramatically reduced aflatoxin levels in corn (see "Protecting Corn From Aflatoxin," *Agricultural Research,* September 2010, pp. 8-10). In the latest round of trials, conducted by Accinelli's group near Bologna from 2009 to 2010, bioplastic formulations of K49 netted similar aflatoxin reductions (65 to 97 percent, depending on where applied).

"We find you get better results from applying K49 when corn is knee-high—or at what's called the '8-10 leaf stage'—than when it's at the tassling or silking stage," says Abbas.

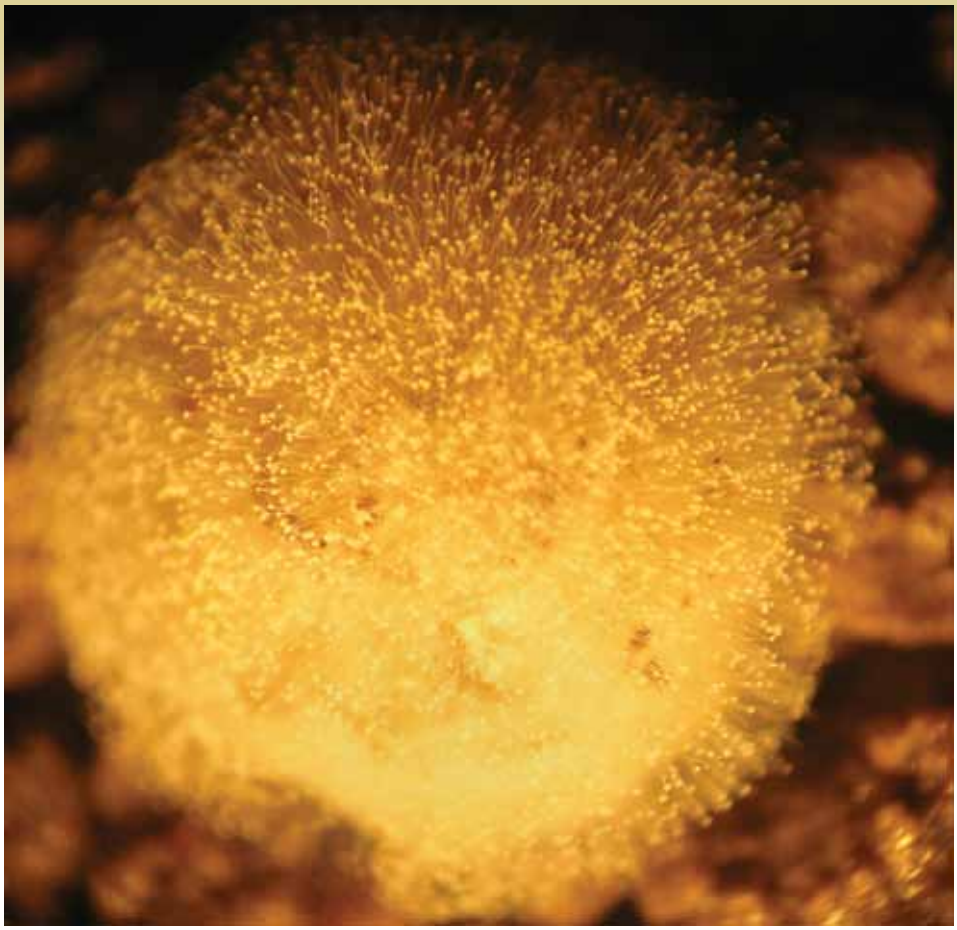
A patent has been filed on the bioplastic formulation, and the researchers hope that its issuance will encourage a biopesticide manufacturer to license the technology and develop it commercially.

Meanwhile, they're comparing different granule sizes to determine which works best with airplane-mounted sprayers, which may make applying K49 more practical for growers. They're also evaluating mixtures of K49 and certain chemical pesticides, as well as other biocompetitive strains, for possible synergistic effects that could improve performance or save on field application costs. In addition, the unique bioplastic matrix may also be effective in delivering other soil-applied fungi for controlling crop diseases. For example, the bioplastic has been shown to be an attractive method of incorporating beneficial *Trichoderma* fungi into potting mix to protect flowers such as impatiens from fungi that cause damping-off disease.

"There's really no one good way of controlling aflatoxins by traditional means—certainly not with chemical fungicides," says Abbas. But combined with resistant cultivars and other measures, a new biocompetitive strain could give corn farmers an added tool to use in fortifying crops against outbreaks that can lead to contamination and costly losses.—By **Jan Suszkiw,** ARS.

This research is part of Plant Diseases, an ARS national program (#303) described at www.nps.ars.usda.gov.

Hamed K. Abbas is in the USDA-ARS Biological Control of Pests Research Unit, National Biological Control Laboratory, 59 Lee Rd., P.O. Box 67, Stoneville, MS 38776; (662) 686-5313, hamed.abbas@ars.usda.gov.



After a bioplastic granule is applied to the soil, the nontoxigenic *A. flavus* fungus grows and sporulates as shown.

DWFP A Battle Plan To Protect

STEPHEN AUSMUS (D2627-12)

At the Center for Medical, Agricultural, and Veterinary Entomology in Gainesville, Florida, scientists set up a tent previously used in Iraq to evaluate how effective different compounds are at protecting an occupant from mosquitoes and stable flies. In the foreground, technician Joyce Urban releases mosquitoes as entomologists Gary Clark (left) and Dan Kline place spatial repellent delivery devices for testing.

U.S. Troops From Harmful Insects

During World War II, U.S. Army General Douglas MacArthur was quoted as saying, "It's going to be a very long war if for every division I have facing the enemy, I have one sick in the hospital and another recovering from this dreadful disease"—meaning malaria. Today, the battle against insects that cause disease is still being fought to help protect deployed U.S. troops and enable them to accomplish their mission.

Mosquitoes, sand flies, ticks, mites, and other biting arthropods transmit pathogens that cause some of the most devastating diseases. Malaria, dengue fever, yellow fever, Japanese encephalitis—all transmitted by mosquitoes—and a host of other diseases affect people around the globe and are a particular problem for militaries that send men and women to places where such illnesses are endemic.

For example, "In 2003, 80 out of 225 U.S. marines deployed on a mission to Liberia came down with malaria, but no deaths were associated with that incident," says U.S. Air Force Lieutenant Colonel Douglas Burkett, research liaison officer with the Armed Forces Pest Management Board (AFPMB). "The trouble with most widely used insecticides is that we have fewer available active ingredients for public-health pest control, and at the same time, we have a global increase in insecticide resistance to our best chemical tools."

The mission of the U.S. Department of Agriculture is critical to the U.S. Department of Defense (DOD), Burkett says. The Agricultural Research Service, USDA's in-house research arm, has excellent research capabilities and is good at developing and testing pesticides and developing application technologies that support public health.

A strong alliance has long existed between USDA and DOD—as far back as 1932, when an entomological research laboratory was established in Orlando, Florida, to combat mosquitoes, filth flies, and disease-transmitting arthropods like fleas and mites.

STEPHEN AUSMUS (D2623-3)

The mosquito *Aedes aegypti* can spread several diseases as it travels from person to person. Only the females feed on blood.

Above: This mosquito is just starting to feed on a person's arm.

Below: The same mosquito has filled up on human blood. In partnership with the U.S. Department of Defense, ARS scientists are working to protect U.S. soldiers from this insect pest and other disease-spreading insects by developing new repellents, treated fabrics, and more.

STEPHEN AUSMUS (D2623-8)

"It was important to have a laboratory in an area where there were a lot of malaria vectors at that time," says Ken Linthicum, director of the ARS Center for Medical, Agricultural, and Veterinary Entomology (CMAVE) in Gainesville, Florida. "During World War II, one of the laboratory's objectives was to determine how to interrupt malaria transmission in the South Pacific to protect soldiers stationed there."

Today, a new battle plan is under way. The Deployed War-Fighter Protection (DWFP) research program was implemented in 2004 to prevent or defend against insect attacks on troops. USDA receives $3 million of the $5 million allotted to the AFPMB by the U.S. Congress each year for research that focuses on developing public-health insecticides, improving personal protection for troops, and devising improved application technologies to kill insects. Remaining funds are distributed through competitive grants to universities, military laboratories, and private industry.

"Across DWFP, we have built a real strong network not only with the U.S. Department of Defense and the USDA, which is what this partnership is all about, but with universities, industry, and others," says U.S. Navy Captain Stanton Cope, former AFPMB director and DWFP manager. "When you consider this program has only been in existence for a short period of time, its outreach and productivity are phenomenal."

In the 1940s, USDA scientists at the Orlando lab, which was later moved to Gainesville and eventually became a part of CMAVE, developed delousing techniques that prevented millions of cases of louse-borne typhus, a disease with a high death rate and no effective treatment at that time. They also created the aerosol spray canister. Other achievements included the discovery of DEET by scientists at the Henry A. Wallace Beltsville Agricultural Research Center in Beltsville, Maryland. Today, DEET remains a primary defense against biting insects.

"DEET is still the best topical repellent we've got," Burkett says. "It has a long safety track record, but some soldiers don't like the odor and feel, and they prefer to have other options."

Initially, DWFP funds were to be used to bring together the skills of scientists at different ARS laboratories—starting with basic ideas that would end with registered products. This goal was mostly achieved, says Dan Strickman, ARS national program leader for Veterinary, Medical, and Urban Entomology. The research team includes 15 scientists at 5 ARS laboratories located in Florida, Maryland, Mississippi, and Texas.

"We're strongest in discovery and have developed entirely new classes of insecticides out of the DWFP program," Strickman says.

Unlocking the Chemistries of Folk Remedies

Some of those discoveries have come from plants gathered in the wild and from traditional folk remedies—two methods used by scientists at the Natural Products Utilization Research Unit in Oxford, Mississippi, to find plant-derived compounds to deter insects.

A story about a farmer in the 1930s crushing leaves of the American beautyberry plant and putting them under the harnesses of stock animals to keep pests away led to the discovery, in that plant, of the compound callicarpenal, which has significant repellency against mosquitoes and ticks. (See "Learning From Our Elders: Folk Remedy Yields Mosquito-Thwarting Compound," *Agricultural Research,* September 2006.)

Working closely with scientists at the ARS Mosquito and Fly Research Unit in Gainesville, Florida, and with Abbas Ali and others at the National Center for Natural Products Research at the University of Mississippi, chemist Charles Cantrell, plant pathologist David Wedge, and research leader Stephen Duke are exploring additional promising compounds from the American beautyberry and other plants to find natural alternatives that are as effective as or better than DEET at repelling arthropods.

Recently, Cantrell examined mosquito-deterrent effects of callicarpenal and looked at an efficient synthetic approach for commercial companies interested in producing it as an insect repellent.

Following up on a tip about people in Africa and India who burn *Jatropha curcas* seed oil in lamps to keep insects out of their homes and other areas, researchers identified which of the oil's components are responsible for mosquito repellency.

In the lab, smoke was extracted from burning *J. curcas* oil and analyzed. A number of active compounds—free fatty acids and triglycerides—were found to be effective at preventing mosquitoes from biting.

PEGGY GREB (D2693-1)

Left: Technician Solomon Green III (foreground) and chemist Charles Cantrell collect leaves from American beautyberry plants in a forest near Oxford, Mississippi. The leaves of the plant contain the mosquito-repelling compound callicarpenal.

Below: Charles Cantrell examines a burning dried male inflorescence from the breadfruit tree *(Artocarpus altilis)*. People in Oceania routinely burned this plant to repel biting insects such as mosquitoes.

PEGGY GREB (D2695-1)

"Fatty acids are well known to have insect repellency," Cantrell says. "We identified the triglycerides as also having repellent activity, the first such report, to my knowledge."

Another possible source of repellents is breadfruit, which contains compounds similar to those in *Jatropha* sp. Cantrell hopes to combine the two sources into a more effective product.

One novel discovery is being kept under wraps for now. Chemist Kumudini Meepagala at the Oxford lab, collaborating with chemist Ulrich Bernier at Gainesville, has developed a natural-product-based mosquito repellent that is more active and lasts three times longer than DEET. A patent application has been filed on this undisclosed compound.

Learning How Repellents Hinder Mosquito Attacks

Another laboratory instrumental to the DWFP program is the Invasive Insect Biocontrol and Behavior Laboratory in Beltsville. Scientists involved in DWFP research there include chemist Kamal Chauhan, entomologist Joseph Dickens, and postdoctoral research associate Jonathan Bohbot. The group develops new chemical tools that are commercially viable and safe for humans, animals, and the environment.

In one study, Bohbot and Dickens sought to determine how the repellents DEET, 2-undecanone, IR3535, and picaridin produce their effects against the yellowfever mosquito. They found that these repellents affect specific odorant receptors in mosquitoes differently—scrambling the insect's ability to detect chemical attractants like octenol.

"We injected frog eggs with the odorant receptor genes that we're interested in, and the synthetic machinery within the eggs produced those receptors and put them in the outer cell membrane of the egg," Dickens explains. "We could then use tiny electrodes placed in the outer cell membrane to record electrical responses resulting from the presence of the odorant receptors."

The effects of the chemicals were then determined by flushing solutions of odorants or repellents over the eggs.

This cutting-edge technology enabled the Beltsville scientists to make a series of important basic discoveries with potential practical applications. Among those discoveries were the identification of the first mosquito receptor that could distinguish mirror images of molecules and individual proteins that recognize different attractants, and learning the way in which insect repellents scramble messages from chemical attractants.

Dickens says these new findings explain in part how repellents work and may be used to discover or enhance repellents in the future, based on their differential effects on specific odor receptors.

Outmaneuvering Mosquitoes

Much of the DWFP research takes place in the Mosquito and Fly Research Unit at CMAVE, where research leader Gary Clark; entomologists Dan Kline, Jerry Hogsette, Chris Geden, and James Becnel; and Bernier evaluate insecticides in the later stages of development and design innovative technology to fight biting insects and other pests.

Their work includes a rapid screening system for compounds to determine insecticidal possibilities, which was developed by Becnel's group. A patent was awarded for a molecular pesticide technology that kills mosquitoes by preventing them from producing proteins essential for survival.

NEIL SANSCRAINTE (D2645-2)

ARS entomologist James Becnel (upper) and molecular biologist Al Estep (Navy Entomology Center of Excellence) inject nucleic acids into mosquitoes to "silence" specific genes.

Another team member, entomologist Sandra Allan in the Insect Behavior and Biocontrol Research Unit at CMAVE, is using toxic sugar-based baits to lure and kill mosquitoes.

"You put this bait or trap out in the environment, and the mosquitoes or sand flies that want to sugar-feed come and feed on the bait, which contains pesticides that kill them," Allan says. "That's really important because mosquitoes and sand flies sugar-feed more often than they blood-feed."

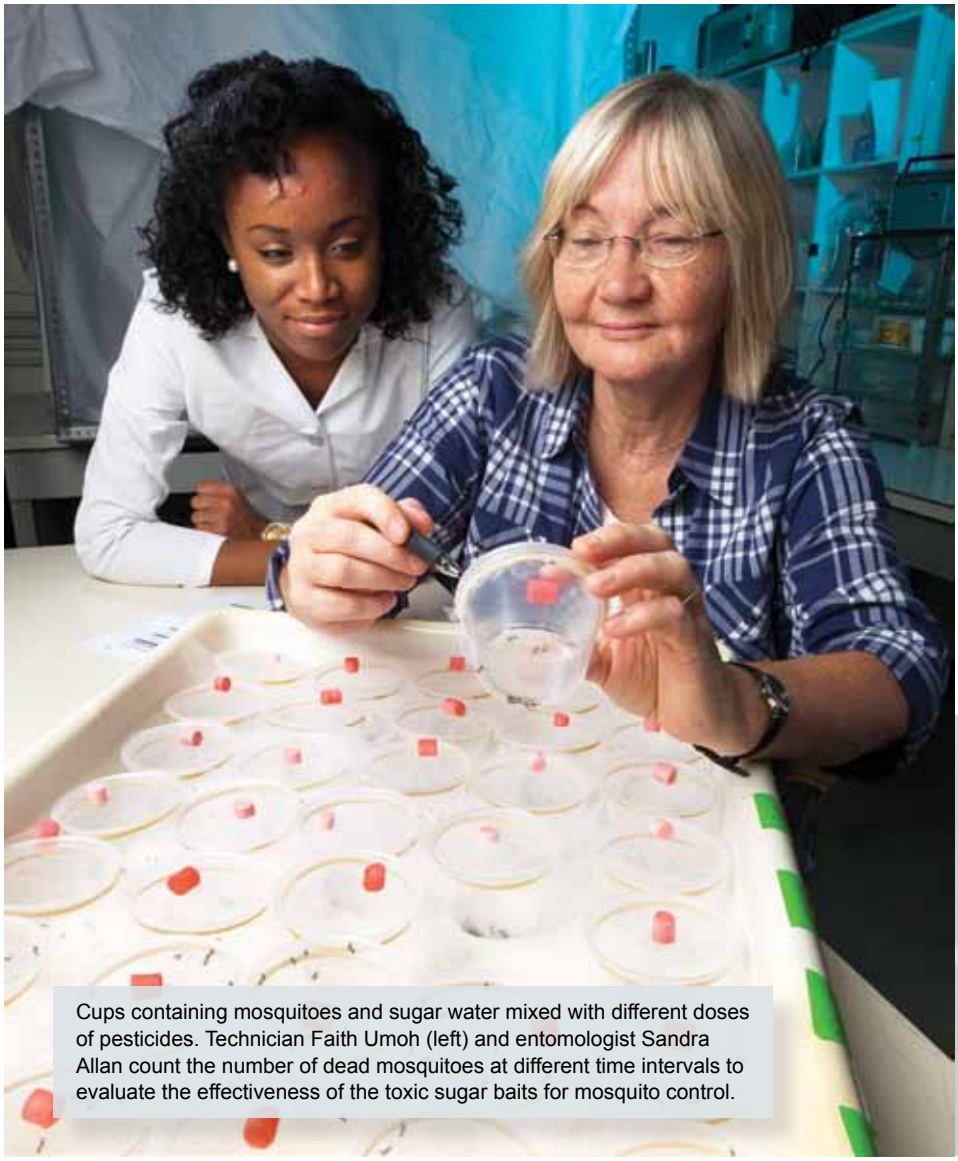
Only female mosquitoes blood-feed, whereas both males and females need to sugar-feed.

Allan looked at different commercial pesticides that include additives allowing them to be dissolved and ingested in water.

"That's important because when the mosquito feeds, it's actually drawing up the pesticide because it's water soluble," Allan says. "Also, using registered, commercially formulated pesticides puts us one step closer to developing end products and getting them out into the field."

In the study, 10 different insecticides were combined with a sucrose solution and fed to females of three mosquito species—*Culex quinquefasciatus,* which transmits West Nile virus; *Anopheles quadrimaculatus,* a malaria vector; and *Aedes taeniorhynchus,* an important pest and vector of some arboviruses.

Compounds from five different classes of insecticide active ingredients—pyrethroids, phenylpyroles, pyrroles, neonicotinoids, and macrocyclic lactones—were toxic to all mosquito species. These compounds could be used to develop toxic baits for the pests, Allan says. The next step is to evaluate these chemicals against sand flies and to determine if one is better than the others.



Cups containing mosquitoes and sugar water mixed with different doses of pesticides. Technician Faith Umoh (left) and entomologist Sandra Allan count the number of dead mosquitoes at different time intervals to evaluate the effectiveness of the toxic sugar baits for mosquito control.

STEPHEN AUSMUS (D2622-3)

New Recruits To Help Fight Sand Flies

STEPHEN AUSMUS (D2642-4)

A sand fly, *Phlebotomus papatasi,* can transmit parasites that cause leishmaniasis, a disease that can cause permanent skin damage and severe organ damage.

Sand flies are another major pest for troops in the Middle East, Afghanistan, and Africa.

"I was one of those guys deployed to Iraq in 2003," Burkett says. "I'm an entomologist. I know how to control sand flies, because I've read all the textbooks. The reality is, when we got there, nothing worked. Soldiers were getting between 100 and 1,000 bites per night from sand flies that were testing positive for the parasites that cause this hideous disease, leishmaniasis."

There are no vaccines or medications to prevent leishmaniasis, nor any way of telling whether a soldier has it until 3 or 4 months after being bitten by a sand fly infected with *Leishmania* parasites, Burkett says. Victims of the disease commonly suffer with permanent skin disfigurement and sometimes severe organ damage.

Two years ago, scientists at the ARS Knipling-Bushland U.S. Livestock Insect Research Laboratory in Kerrville, Texas, joined the DWFP team to help find ways to kill sand flies. Entomologists Andrew Li, Adalberto Pérez de León, and their colleagues started a sand fly colony to evaluate new insecticides and repellents, develop formulations, and design diagnostic tools for rapid detection of resistance.

"Our project focuses on screening insecticides that are available on the market to

see which ones are more effective," Li says. "The information we gain will be helpful to the military and the public in choosing insecticides to control the sand fly."

Only a few studies have addressed sand fly resistance to pesticides, so Li is looking at sand fly genes to find answers. He is developing a test for detecting mutations responsible for resistance.

Another laboratory looking for solutions is the ARS European Biological Control Laboratory in Thessaloniki, Greece. With funds from the DWFP program, ARS hired Alexandra Chaskopoulou, a native of Greece and a postdoctoral research associate, who is examining sand fly populations that transmit leishmaniasis in her country.

Fighting Filth Flies

(D2620-1)

The adult stable fly, *Stomoxys calcitrans,* is one of many biting, blood-feeding insects.

Nonbiting flies that shuttle between filth and food spread bacteria that cause diarrhea, the most common reason for absence from duty in the U.S. military.

"In my experience in the military, every time there was an outbreak of flies, there was an increase in the disease rate and a big increase in diarrhea," Strickman says. "When we controlled flies, we brought that down."

Not to be outflanked, scientists are working with a number of products and techniques that involve testing new traps, finding insecticides that work, and developing new methods to control this nuisance.

CMAVE's Geden recently teamed with researchers at an Australian public-health agency to determine whether an insect growth regulator called "pyriproxyfen,"

At Gainesville, Florida, entomologist Chris Geden sets up an autodissemination device for flies in an outdoor screenhouse. Flies are attracted to the device by an olfactory lure and become covered with pesticide dust, which they carry back to larval development sites.

STEPHEN AUSMUS (D2619-4)

STEPHEN AUSMUS (D2628-4)

Entomologist Jerry Hogsette sets out stable fly traps and targets for a field study. Stable flies breed in manure, wet straw, and decaying vegetation, and they feed on the blood of livestock and people. Expertise gained in field tests for controlling these flies and other biting insects helps ARS scientists find the best insect controls for the military, farmers, and consumers.

which was successful in controlling mosquitoes, could also kill house flies.

"Pyriproxyfen mimics a hormone in the larval fly," Geden says. "When it's applied in sufficient quantities to larval breeding sites such as manure, insects become stuck in the immature stages and they never become adults."

The greatest potential for pyriproxyfen may be via autodissemination, a process in which adult flies are treated with pyriproxyfen that they later transport to egg-laying sites, he says.

Geden treated gravid females—those with eggs—with a dust containing pyriproxyfen and then allowed the flies to lay their eggs on a larval medium. All immature flies died in the pupal stage. This approach would eliminate broadcast application of the insecticide and take advantage of fly behavior to deliver the pyriproxyfen to targeted larval-breeding sites, Geden says. Scientists looked at the dosages required to kill house flies, the potency needed, different formulations, and the amount a fly can carry to the larval habitat.

"We found the material extremely effective at low dosages for house flies and that flies are capable of carrying enough back to their breeding sites to prevent the maturation of immature flies," Geden says. "We're now working with new formulations of higher potency to improve this system."

On a different front, CMAVE's Hogsette is working with University of Florida scientists to find more effective methods for baiting and trapping flies.

"House flies can use a wide range of larval development media—almost anything that's moist—and can develop from the egg to the adult stage in just 6½ days," Hogsette says. "Multiple traps may be required at capture sites to effectively reduce house fly populations, but research is needed to determine just how many are needed."

What To Wear

Factory-treated uniforms that repel insects are the latest in protective fashion for deployed troops. Attachable bands that offer additional protection may be in style for the future.

"The more proficient we are at repelling or killing insects, the better our ability to prevent disease transmission to our troops when they are deployed," Bernier says.

Bernier and textile chemist Melynda Perry of the U.S. Army Natick Soldier Systems Center evaluate the quality of permethrin-treated uniforms and fabric. The testing-and-evaluation process is an outcome of efforts made in 2003 by the U.S. Marine Corps to stock combat uniforms that were factory treated with permethrin. The initial specifications to qualify permethrin-treated uniforms were drafted in 2006.

Research on U.S. Army uniforms is conducted by Bernier, Perry, and Neal Nguyen of the Program Executive Officer Soldier at Fort Belvoir, Virginia.

Treated uniforms have been standard practice since 1951, when an ARS-developed miticidal mixture, M-1960, was used. M-1960 was discontinued in 1982 because it was a skin irritant. ARS scientists developed a permethrin treatment of uniforms, and field treatment of cotton uniforms with this repellent became available in 1991.

Since then, new uniforms have been introduced, and many incorporate fire-resistant fibers. Application of permethrin to these uniforms is not possible without factory treatment.

Bernier developed a bite-protection assay to test how well uniforms protect the wearer from mosquito bites. It requires that a human volunteer wear a tightly sewn uniform sleeve and then insert the covered arm into a cage of mosquitoes.

"We use human volunteers because, in the real world, humans wear these uniforms," Bernier says. "It's far better to figure out the best treatment here at home, before the uniforms are worn in the field and we end up having missions fail."

"I was one of those guys deployed to Iraq in 2003. I'm an entomologist. I know how to control sand flies, because I've read all the textbooks. The reality is, when we got there, nothing worked. Soldiers were getting between 100 and 1,000 bites per night."—Douglas Burkett

Uniform fabric specimens are tested to determine their ability to provide protection initially and after 20 and 50 launderings. So far, a total of 65 U.S. military uniform constructions and compositions have been evaluated.

In 2011, scientists examined alternative fabrics for potential replacement of the original fire-resistant Army combat uniform. Fabric replacement was necessary because the material initially selected was too easily torn. Earlier this year, Bernier completed bite-protection testing on uniforms constructed of this more durable fire-resistant fabric.

Bernier and chemist Chauhan have created an attachable repellent-treated band that augments the uniform by conferring some spatial protection to exposed skin. Preliminary evaluations indicate that the band may have additional use for travelers against bed bugs, Chauhan says.

"We've achieved protection for the uniform, but our ultimate goal is a stand-alone product, so even without the uniform, you can put the band on the sleeve or collar to protect that area for a long period, and it can be used again and again," Chauhan says.

The U.S. military treats uniforms with permethrin to prevent mosquitoes and other insects from biting. At Gainesville, Florida, chemist Ulrich Bernier (right) tests a treated uniform to see whether it prevents mosquitoes from biting. In the background, technician Greg Allen studies how well mosquitoes are attracted to various test substances.

STEPHEN AUSMUS (D2624-2)

Chauhan has filed for a patent on another new product—a disposable, reversible bandage—for short-term protection. The invention also has potential application for recreation and sports use and as a device to protect pets and livestock from biting insects.

Rounding Up the Best Equipment

Each year, ARS scientists at the Southern Plains Agricultural Research Center (SPARC) in College Station, Texas, pack up and head off to an equipment rodeo—the Annual International Equipment Evaluation—at the Navy Entomology Center of Excellence (NECE) at Jacksonville Naval Air Station in Florida.

The team from NECE and the SPARC Areawide Pest Management Research Unit's Aerial Application Technology group "round up" sprayers of all shapes and sizes—hand-held, backpack, truck-mounted, and thermal foggers with water and oil-based sprays and insecticides—used in insect-control applications.

> "Whenever you get a new compound that works well in the laboratory, you have to take it to the field to make sure it's useful in the real world."
> —Dan Kline

"Manufacturers operate their own equipment, and all testing is done out in the open," says SPARC agricultural engineer Clint Hoffmann. "The good and bad results are published on all equipment tested."

So far, the group has developed droplet size spectra for about 88 sprayers.

"We think we've tested every piece of equipment that's in the military arsenal," Hoffmann says.

"Adding this group of engineers that work with droplets and machinery has given a huge boost to this program," Burkett says. "They have a lot of expertise for area application sprayers, and they find out

At a remote patrol base in Iraq, ARS scientist and U.S. Army medical entomologist Seth Britch applies a residual treatment of lambdacyhalothrin to camouflage netting and shade cloth that will be suspended over outdoor eating and cooking areas and over areas in between dormitories. This residual pesticide treatment reduces populations of biting flies and mosquitoes by transferring lethal doses to the insects when they rest on the camouflage material while seeking human hosts.

SETH BRITCH (D2643-1)

SETH BRITCH (D2644-1)

In Marigat, Kenya, Kenneth Linthicum, the director of ARS's Center for Medical, Agricultural, and Veterinary Entomology in Gainesville, Florida, calibrates a thermal fogger in preparation for experimental applications of aerosol pesticides to control sand flies. The trials at Marigat use both ultra-low-volume and thermal fog equipment and a variety of EPA-labeled pesticides and are the first of their kind in providing critical information to better target sand flies in hot, arid locations.

what works and what doesn't, which is a great benefit to the military."

Scientists use the most accurate measuring tool, a laser diffraction instrument, to measure spray droplet sizes, test active ingredients, and capture data. Studies have led to the development of a user-friendly smartphone application that can be downloaded to help users select spray equipment and optimize spray settings, says agricultural engineer Brad Fritz. (See story on page 15 for details.)

Taking It to the Field

"Whenever you get a new compound that works well in the laboratory, you have to take it to the field to make sure it's useful in the real world," says CMAVE's Kline.

Spatial repellents are used in field conditions to significantly reduce the number of mosquitoes and other biting insects in a specific area over a certain period of time, he says. The criteria for insecticides depend on the situation.

"For example, the individual soldier may be on sentry duty, not moving," Kline explains. "Special operations teams may be hiding out, looking for terrorists. Then you may have a community of soldiers in a tent or encampment where dimensions may vary."

In one experiment, scientists set up tents previously used in Iraq to evaluate how effective different compounds are at protecting an occupant from mosquitoes and stable flies. (See photo on page 4.)

"Many of the applications tested were not practical for soldiers, which is why there's a need for a better delivery system and one reason why treating uniforms with compounds is critical," Kline says.

"We go to a desert, like the Coachella Valley in California, that is similar to desert environments in the Middle East where U.S. troops are deployed," says Linthicum, "and we're able to evaluate the effectiveness of various equipment and treatment methods."

Tents, camouflage screening, sun awnings, and other structures of deployed units can be treated quickly using spray equipment currently issued to preventive-medicine units, Linthicum says.

Studies have shown that insecticide treatment of woodland-pattern military camouflage netting is long lasting and effective at reducing mosquitoes. Seth Britch, an entomologist at CMAVE and a captain in the U.S. Army Reserve, demonstrated that desert-pattern camouflage netting can also be treated to provide effective protection against mosquitoes and sand flies in a hot, arid environment.

The study involved spraying specially formulated insecticides onto the netting. Once dry, the residual treatment forms a barrier that is toxic to insects, Britch says.

The material was then packed in a conex cargo container and shipped to Tallil Air Force Base in Iraq, where it was stored for 5 months and then tested from March-June 2010. The netting was sent back to CMAVE for analysis.

"After almost 300 days, we were still getting good control of mosquitoes," Linthicum says.

In another experiment, Britch, Linthicum, and Todd Walker, an entomologist formerly with NECE, evaluated the performance of ultra-low-volume pesticide spray equipment, chemicals, and techniques in Kenya against sand flies for the first time. They tested two pesticide sprayers and two pesticides against wild and colony-reared sand flies as proxies for similar sand fly species and similar environments found in Iraq and Afghanistan. They demonstrated that current DOD equipment and one pesticide performed well against sand flies in a hot, arid environment.

Getting Products to Troops

Using funds from the DWFP program, ARS and the Interregional Research Project No. 4 (IR-4) signed a cooperative agreement to establish the IR-4 Public Health Pesticides Program to facilitate registration of new uses of chemicals.

"One of the reasons the IR-4 project was brought into the mix is because we have worked in the public sector almost 50 years to provide an avenue to get these minor-use products into the hands of IR-4's traditional stakeholders—the growers of fruits, vegetables, herbs, and other specialty crops," says Jerry Baron, executive director of the IR-4 project.

The roles of IR-4 are to make sure insecticides are safe, to work with the U.S. Environmental Protection Agency in getting products registered, and to find active ingredients that already have registrations for other purposes that may have public-health applications, says Karl Malamud-Roam, manager of the IR-4 Public Health Pesticides Program.

"We work hard to maintain registration of existing, useful public-health products and to ensure that the registration process is as smooth and efficient as possible," Malamud-Roam says.

There are many good ideas in the minds of scientists, military experts, and academic and industry partners, and in chemical libraries, Malamud-Roam says. There's also a product-development pipeline that sometimes gets clogged.

"IR-4 has traditionally been like a regulatory plumber," he says. "Our job is not to make discoveries, like new molecules. We leave that to other scientists. Our job is to figure out how to get molecules from the idea stage to product registration."

More than 330 scientific papers have been published by researchers since the DWFP program began. Most of this research, about 81 percent, is the work of ARS scientists.

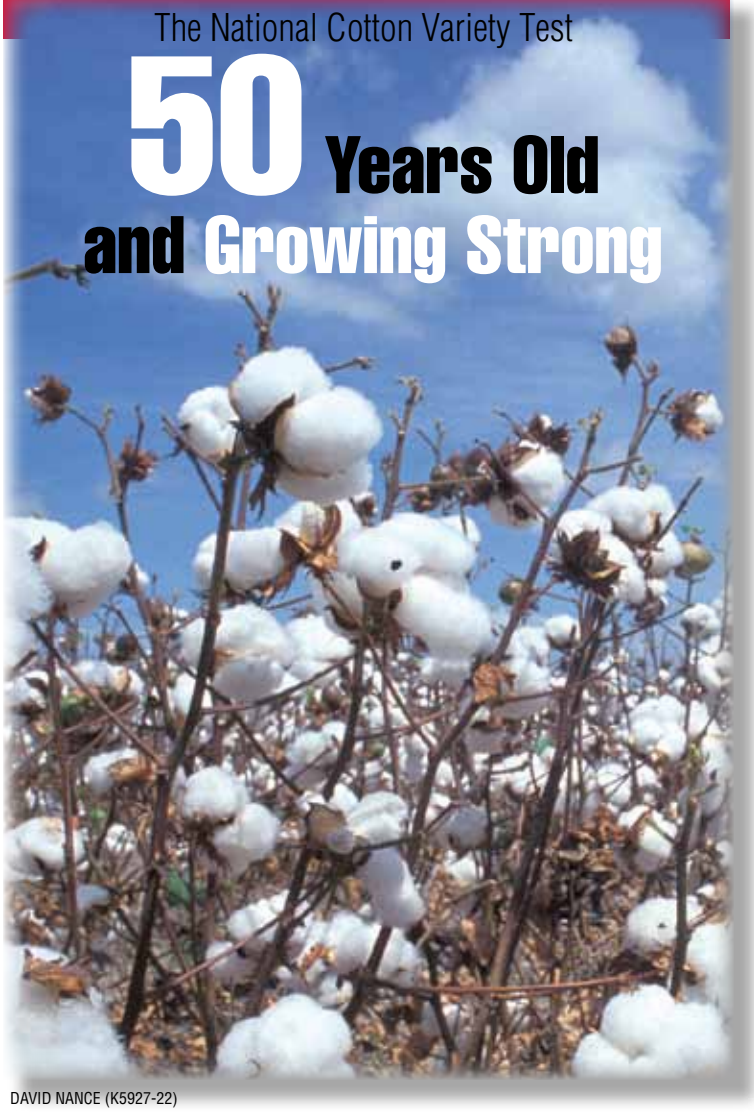
"This is what it's all about," Burkett says. "This is what keeps programs alive. When funds are put into research programs like DWFP, discoveries are made, collaborations are built, and it actually results in tangible products that we can get into the hands of soldiers to kill bugs."—By **Sandra Avant,** ARS.

This research is part of Veterinary, Medical, and Urban Entomology, an ARS national program (#104) described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Sandra Avant, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1627, sandra.avant@ars.usda.gov.

The National Cotton Variety Test

50 Years Old and Growing Strong



DAVID NANCE (K5927-22)

Quite a bit of science has gone into American cotton over the years. Take, for example, the Agricultural Research Service-led National Cotton Variety Test (NCVT). Celebrating its 50th anniversary this month, the NCVT was originally created in 1960 to standardize collection and analysis of field data necessary for objectively evaluating new upland and pima varieties.

To that end, the NCVT called for partitioning the U.S. Cotton Belt—which spans from Virginia south to Georgia and west to southern California—into six distinct growing regions, dubbed Eastern, Delta, Central, Blackland, Plains, and Western. A separate test was organized in 1961 for pima cotton species. This arrangement has allowed researchers to systematically test new, region-specific varieties and establish national standards in every test to serve as a link between regions. The four or five national standards are designated for 3-year cycles, and at the end of the cycle, two or three of these varieties will be replaced by new national standards.

ARS geneticist Charles F. Lewis was the principal organizer and motivator for the NCVT. The test was organized to encourage the sharing of exotic germplasm and breeding information. Its design also allows for appropriate statistical analysis and flexibility in the management of test locations.

To date, the NCVT program has tested more than 1,300 varieties, germplasms, and strains. In 1964, a special test called the "regional high quality" (RHQ) test was organized and extends across five of the six national regions. "Periodically, we compare the top cotton varieties of yesteryear with those of today to measure our breeding progress," says geneticist William R. Meredith, Jr., in ARS's Crop Genetics and Production Research Unit at Stoneville, Mississippi.

One of the greatest accomplishments coming out of the RHQ program was the release of variety DES 56. The parents of this variety were ARS germplasm PD 2-164 and the commercial variety Stoneville 213. DES 56 is the parent or grandparent of almost all varieties grown in the Eastern, Delta, and Central regions (encompassing South Carolina, North Carolina, Virginia, Alabama, Mississippi, Missouri, Louisiana, and Texas).

The data amassed by the program—which is analyzed by Meredith's and other labs and published annually in reports—documents notable cotton-production trends. The data also helps to determine the contributions of genetics, locations, years, and crop-management methods to fiber yield and quality.

As a result, new regions were established and others modified. A major change in variety testing occurred in the mid-1990s with the introduction of transgenic cottons that resist caterpillar feeding and tolerate glyphosate herbicides.

"Through breeding, many changes have taken place in the characteristics of cotton varieties. Seed and boll (cotton's fruit) have decreased, and the lint percentage and yield have increased," says Meredith. "Cotton today is grown in a much more eco-friendly manner than 50 years ago. Now, much less insecticide and herbicide are applied. You get a much better product and better quality cotton at a cheaper price."

ARS coordinates the program, and other key players include state experiment station personnel who conduct the tests, cotton growers and other industry members, trade groups like the National Cotton Council of America, and agricultural companies. Cooperation is especially critical as American cotton faces increasing competition from abroad, other cash crops, and the synthetic-fibers market.

As it has in the past, the NCVT will prove useful as both a chronicle of change and a guide with which to navigate it.—By **Jan Suszkiw,** ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement, an ARS national program (#301) described at www.nps.ars.usda.gov.

William R. Meredith is in the USDA-ARS Crop Genetics and Production Research Unit, 141 Experiment Station Rd, Stoneville, MS 38776; (662) 686-5322, bill.meredith@ars.usda.gov. ✸

Better Ballfields and Rain Gardens Start Below the Surface

STEPHEN AUSMUS (D1976-3)

ARS hydrologist Douglas Boyer (right) and Beckley Sanitary Board operations manager Jeremiah Johnson discuss the performance of a rain garden constructed from local materials. The rain garden is being tested for its ability to reduce storm water runoff, increase infiltration, and remove excess nutrients and other pollutants from the runoff water before it gets to streams or other bodies of water.

The townspeople of Beaver and Beckley, West Virginia, soon may not have to look any farther than their neighborhood ballfield or rain garden to see the benefits of Agricultural Research Service (ARS) research.

The Appalachian Farming Systems Research Center (AFSRC) at Beaver, West Virginia, is the only ARS lab working on constructed or replacement subsoils and topsoils for growing better turfgrass on ballfields, for growing rain gardens that not only reduce rain runoff but also clean pollutants from rainwater, and for growing vegetation on former mineland.

National Turfgrass Research Initiative Works With ARS

The constructed-soil initiative is in its fourth year. ARS is doing the research in cooperation with the National Turfgrass Research Initiative, Inc., a joint turfgrass industry/ARS program created in 2007.

The initiative partners the expertise of ARS and universities. The turfgrass industry has set a high priority on improving degraded soils by constructing soils that include readily available rural, urban, and industrial byproducts that can be mixed with local soils.

Working With Everybody

ARS lead scientist Rich Zobel and the soil resource management team at AFSRC work with USDA's Natural Resources Conservation Service (NRCS); the city of Beckley, West Virginia; the Raleigh County Solid Waste Authority; West Virginia State University at Institute; West Virginia University at Morgantown; Virginia Tech at Blacksburg; the University of Ohio at Akron; and various ARS labs, including two regional research centers. Two local groups interested in water resource management and the U.S. National Park Service are also doing rain garden projects.

Zobel says these collaborations "add expertise in civil engineering, economics, landscape design, and environmental regulation."

Zobel and research associate Amir Hass, who is with West Virginia State University and stationed at Beaver, work with Doug Boyer, a hydrologist, Charlie Feldhake, a soil scientist, and Javier Gonzalez, a soil chemist, all at AFSRC.

Constructed soil is a much more sophisticated version of the home gardener's method of improving the soil by blending in sand, topsoil, and organic amendments such as humus, composted manure, sewage sludge, or yard and garden clippings.

A good constructed soil goes way beyond these conventional recipes. Research and chemical analyses are used to determine what is needed to ensure that soil does not become compacted and has excellent drainage, water-holding capacity, and aeration properties, plus essential nutrients for robust plant growth.

SUSAN BOYER (D1983-1)

ARS plant physiologist Rich Zobel (left) discusses the subsoil compaction plots with James Allen, director of Raleigh County Solid Waste Authority. Study results will likely shape future recommendations for athletic fields and home lawns.

Subsoil compaction plots before topsoil is added. The red/orange subsoil is a Greenbrier County (West Virginia) limestone-based soil. The lightest colored plots are Raleigh County (West Virginia) sandstone, and the darker subsoils are Raleigh County shale.

Finding the Best Soil Recipes

Zobel and colleagues are formulating recipes for constructing "designer soils" from various source materials in Ohio, Kentucky, Tennessee, West Virginia, Virginia, and southern Pennsylvania and using materials such as mine spoils, coal-combustion byproducts, poultry litter, and biochar as amendments.

So far, the most promising mixture contains quarry byproducts and composted chicken litter. It has met predetermined requirements such as the ability to transmit stormwater and sustain turfgrass or other vegetation. Chicken litter is the best organic component found so far. Chicken litter is a mixture of droppings and bedding materials—usually sawdust and wood shavings. The litter is composted in a "digester," designed by West Virginia State University, to stabilize the mixture and remove odors and harmful microbes. Three years of testing have shown the composted poultry litter works as well as commercial fertilizer in establishing vegetation on the mined soils.

Fixing Compacted Ballfields

Zobel is initially focusing on compacted soils. He says, "Soil compaction is the first cause of problems in growing good, robust grass on ballfields and other sites. Compacted subsoil causes the grass roots to stop short, restricting the amount of soil water available. These grasses grow weakly and are easily killed by heavy use of the site."

The scientists established experiments at the Raleigh County landfill site. They have several students from Virginia Tech working on various projects to design the specifications for bringing former landfills back into use as ballfields or residential or commercial sites.

At the landfill site, they are testing subsoils with varying levels of compaction overlain with three depths of topsoil. They will plant turfgrass and determine which combinations provide the most suitable turf. From this will emerge the best management practices for building subsoil and topsoil for playing fields. As part of the project, Virginia Tech researchers are also testing nearby football and soccer fields for compaction and nutrient content to determine recommendations for field renovation specifications.

Rain Gardens Sprouting Up Everywhere

Rain gardens are increasingly popular with homeowners and municipalities and are mandatory for many communities nationally. They are plantings in manmade depressions that catch stormwater runoff from sidewalks, parking lots, roads, and roofs. Rain gardens are constructed in various shapes and sizes, from large basins carved by front-end loaders to small streambed-like formations complete with pebbles. Not only do rain gardens slow water down to give it time to soak into the ground and be used by plants, but they also filter out sediment and chemical pollutants.

Many gardens use mainly native flowers with some grasses, but the "constructed swale" type of rain garden uses turfgrass. The only water the plants receive is the runoff from rain. Homeowners usually direct the runoff from their rain gutter downspouts with lengths of plastic corrugated drainage pipe.

"Some rain gardens, as well as ballfields, have had to be torn out and rebuilt because they weren't built right," says Kevin Morris, executive director of the National Turfgrass Evaluation Program. "You have to draw on scientific research to get fields and rain gardens right the first time."

Biochar To Clean Rain Garden Water

Hass, Gonzalez, and Zobel want to take that several steps further. They are working with the ARS Southern Regional Research Center (SRRC) in New Orleans, Louisiana, and the ARS Eastern Regional Research Center in Wyndmoor, Pennsylvania, to use biochar in rain garden soils to neutralize fertilizers, pesticides, and chemicals leaked by cars. The most familiar example of biochar is the activated charcoal used in aquarium filters. Biochar is produced by subjecting materials such as coal to either gasification or pyrolysis. These are both extremely high-temperature processes that take place in the absence of oxygen.

SRRC chemists Isabel Lima and Wayne Marshall (now retired) developed an ARS-

STEPHEN AUSMUS (D1973-6)

Chemist Javier Gonzalez analyzes the composition of water-soluble organic matter from biochar. Biochar is being tested as a soil amendment to improve productivity of marginal soils.

patented method for turning agricultural biowaste into material similar to activated charcoal. But their materials are superior to activated charcoals.

Hass, Gonzalez, and Zobel are cooperating with colleagues at the regional research centers who are interested in biochar made from a mixture of poultry litter and peanut shells. They found that poultry litter biochar is a powerful pollutant magnet. It can attract heavy metals such as copper, cadmium, and zinc, which are ordinarily tough to snag, from wastewater.

Zobel is experimenting at two demonstration rain gardens in the Beaver area, as well as at plots at a county landfill and a mineland reclamation site.

Money for Sporty Topsoil

Morris says, "There is money for constructed-soil research for golf courses and college and professional-level playing fields, but not for sports fields at the high school, elementary school, or park levels—until now. The costs are lowered by using inexpensive byproducts available locally."

STEPHEN AUSMUS (D1974-2)

In simulated rain garden trials, technician Gary Lambert collects leachate to identify plants best able to slow movement of water, nutrients, and fecal bacteria through soil.

From their past research, ARS scientists know that certain soils are unusable for ballparks and rain gardens because they tie up phosphorus, making it unavailable to plants. Therefore, ARS is working with the West Virginia Natural Resources Council and NRCS to develop a computer model that will help users choose which local soils are best for ballparks, soccer fields, rain gardens, and other uses. It will use the NRCS soil survey data, the first such use of this data.

Natural Turf vs. Artificial Turf

"Natural turf can get a bad name from overuse of poorly constructed fields," Morris says, "but it is an inexpensive alternative to artificial turf. It can compete well when everything works. Natural turf has all the resiliency of artificial turf."

Over the long term, Zobel envisions new turfgrass varieties, possibly perennial ryegrass and tall fescue, that will penetrate compacted soil and renovate fields without the need to till the compacted soil. "We have a lot of information from previous research on roots, soils, and microbes that we can draw on for the constructed-soil project," Zobel says. He sees an eventual extension of the constructed-soils research and demonstration projects to homeowners and homebuilders for improving their lawns and rain gardens.

This research should one day help provide specifications for improved turfgrass fields that even the smallest of parks and schools can afford.—By **Don Comis,** ARS.

This research is part of Soil Resource Management (#202), an ARS national program described at www.nps.ars.usda.gov.

To reach scientists mentioned in this article, contact Don Comis, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1625, donald.comis@ars.usda.gov. ✻

Using Manure To Mend Mine-Damaged Soils

From 1850 to 1950, the Tri-State Mining District of southwestern Missouri, southeastern Kansas, and northeastern Oklahoma produced 50 percent of the zinc and 10 percent of the lead in the United States. The last active mine closed in 1970, but mining's ecological legacy remains throughout the region—lead-contaminated acidic soils, toxic smelter sites, large quantities of mine tailings called "chat," and thousands of acres of land with little or no vegetation.

Paul White, a soil scientist in the ARS Sugarcane Research Unit in Houma, Louisiana, was part of a team that studied whether adding beef cattle manure compost to postmining sites would help jump-start revegetation. "Soil microbes recycle nutrients from soil organic matter, and this nutrient cycling is important for vegetation growth. But there is limited soil organic carbon at these sites," White says. "So we added carbon to the soil via compost to see if that would get these systems going."

Kansas State University agronomy graduate student Luke Baker and professor Gary Pierzynski also partnered in this project.

The scientists also wanted to see whether compost could reduce levels of lead and zinc that could contaminate runoff during heavy rain. High levels of zinc can harm aquatic fauna in surface waters, and lead is linked to a number of serious health conditions in humans. Heavy metals in soils also disrupt the activity of soil microbes by damaging proteins or disrupting cell membranes.

The researchers amended soils in 3- by 6-foot test plots with either 20 or 120 tons of beef cattle manure compost per acre. No manure was put on control plots. Then they applied switchgrass seed on all of the plots and took soil samples from the plots five times during the 2-year study.

Two years after they amended the plots with the compost, White and his colleagues found that soils in the high-compost plots had significant increases in pH, plant-available phosphorus, total nitrogen, carbon, and available water. High-compost amendments also increased microbial biomass, enzyme activity, and nitrification potential, all of which create and support favorable conditions for plant establishment and growth.

"Nitrification potential is a sensitive indicator of stress because nitrifying bacteria are especially sensitive to toxic conditions," White explains. "Soil microbes also produce the enzymes that convert organic phosphorus into an inorganic form that can be used by plants."

In this study, the researchers also found that high rates of compost lowered lead and zinc availability by about 90 percent, which may reduce the amount of lead and zinc that could run off and pollute nearby waterways. This reduction occurred because heavy metals generally bind tightly to the organic matter in composted material, which limits their solubility and potential bioavailability in soil. Since high levels of bioavailable zinc inhibit plant growth, this binding action also helps to promote the establishment of a vegetative cover, which in turn can minimize runoff and soil erosion.

Given these findings, White and his partners think that adding composts to contaminated soils could help stabilize postmining sites. "The results strongly suggest that available soil carbon—which we were able to provide with the compost—may be a critical variable in establishing and maintaining a healthy microbial population in soils contaminated by similar mine wastes," White says.

The team published their findings in *Applied Soil Ecology* in 2011.—By **Ann Perry,** ARS.

This research is part of Water Availability and Watershed Management (#211) an ARS national program described at www.nps.ars.usda.gov.

Paul White is in the USDA-ARS Sugarcane Research Unit, 5883 USDA Rd., Houma, LA 70360; (985) 872-5042, paul.white@ars.usda.gov.

A study plot after beef cattle manure compost was added to soils degraded by mining. Compost can increase soil pH, plant-available phosphorus, total nitrogen, carbon, and available water to support plant establishment.

LUKE BAKER, BROOKSIDE LABORATORIES, INC. (D2678-2)

A plot showing varying vegetation that occurred after different levels of beef cattle manure compost amendments. Plant growth suffered when no compost was used but excelled when high amounts were used.

LUKE BAKER, BROOKSIDE LABORATORIES, INC. (D2678-1)

Carefully Unraveling the Intricacies of Biochar

DAVID LAIRD (D2343-1)

When fires burned freely across the North American prairies, they left behind charred material that helped form the region's dark, fertile soils. In South America, pre-Columbian Indians used slash-and-char practices to clear land for farming, which incorporated large amounts of char into the highly weathered soils of the Amazon. This char became a key building block in the development of the rich "terra preta"—or black earth—that sustained agriculture in the Amazon for more than 1,000 years.

Today, Agricultural Research Service scientists are learning more about "biochar," the name for the charred biomass created from wood, plant material, and manure that has been used to improve soil fertility and remediate environmental contaminants. The multi-location effort is still under way, but preliminary results suggest that adding

REBECCA COCHRAN (D2344-1)

Bulk hardwood biochar prior to application on plots near Ames, Iowa.

biochar to agricultural soils could rebuild soil fertility levels and improve nutrient and water retention. Biochar can even "sequester" carbon from plant materials by storing it underground, where it slowly decomposes and makes only a minimal contribution to the emission of the greenhouse gas carbon dioxide. So ARS scientists are working diligently—and carefully—to understand how biochar interacts with soil and crops so that the potential benefits observed in the laboratory can become economically viable realities in the field.

First Steps

Much of the ARS field work on biochar started at the National Laboratory for Agriculture and the Environment (NLAE) in Ames, Iowa. During November 2007, NLAE scientists began the first of six multi-year field studies at ARS locations around the country to assess how biochar affects crop productivity and soil quality. NLAE scientists amended 24 plots (almost 8 acres) of corn with biochar made from hardwood biomass. Twelve plots had almost 8,800 pounds of biochar per acre, and 12 had almost 16,000 pounds per acre. But no significant difference was observed in the 3-year average grain yield from either treatment.

Other small-scale ARS field and laboratory studies in Idaho, Kentucky, Minnesota, South Carolina, and Texas showed that hardwood biochar could improve soil structure and increase the ability of sandy soils to retain water. But soil fertility response was more variable.

These results underscore what ARS scientists already knew: Biochar characteristics vary widely, depending on the feedstock used to make it, the time spent in the pyrolyzer—a device that uses heat to break down the biomass in the absence of oxygen—the temperature used during pyrolysis, the feedstock's moisture content, and other factors. Because of structural differences, some biochars break down more quickly in soil than others. Biochars can also differ in particle size, porosity, surface area, pH, and biologically active and available compounds. So even though there's already a lot of public enthusiasm about using biochar in agricultural production, ARS scientists are much more cautious about the possibilities.

Biochar pellets in Prosser, Washington, made from dairy cow manure and used to capture phosphorus from dairy lagoons.

ARS soil scientist Doug Karlen, who is the research leader of the ARS Soil, Water, and Air Resources Research Unit at NLAE, has been involved with the biochar studies from the outset. "Now we're studying how crops respond to soils that have been amended with biochar made from corn stover," he says. "We didn't see a significant response when we amended an acre with 8 tons of biochar made from hardwood, so now we're amending fields with as much as 50 tons of corn stover biochar per acre."

Finding What Works Where

"We need to make sure that the biochar will actually improve the condition of the soil where it is being used," says soil scientist Jeff Novak, who coordinates the ARS multi-location effort to learn more about biochar dynamics under different real-world field conditions. "We want to ensure that the correct biochar is applied to the right soil so that we avoid decreasing soil quality."

Novak, who works at the ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina, is working with other scientists to manufacture "designer biochars" with properties tailored to remediate specific soil characteristics. He led a laboratory study to learn more about the characteristics of different biochars and to see which biochars could improve the sandy soils found on the Carolina coastal plain and the silt loam soils of the Pacific Northwest, which are derived from volcanic ash and windblown sediment known as "loess."

Several other Florence researchers, including soil scientist Warren Busscher, environmental engineer Kyoung Ro, agricultural engineer Keri Cantrell, and microbiologist Tom Ducey, participated in the study. Other ARS partners included chemist Isabel Lima, who works in the ARS Commodity Utilization Research Unit in New Orleans, Louisiana; soil scientist Jim Ippolito, with the Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho; and ecologist Harry Schomberg at the J. Phil Campbell Sr. Natural Resource Conservation Center in Watkinsville, Georgia.

The team made biochars from peanut hulls, pecan shells, poultry litter, switchgrass, and hardwood waste products. By pyrolyzing these materials at different temperatures, the researchers produced nine different types of designer biochars.

Lettuce growing in Minnesota field plots amended with 20,000 pounds of macadamia nut shell biochar per acre. The study evaluated how the biochar affects crop yield, soil fertility, and greenhouse gas production from the field.

AMANDA BIDWELL (D2345-1)

PEGGY GREB (D2326-1)

ARS soil scientist Jim Ippolito conducts analysis of essential plant elements from soils amended with biochar in Kimberly, Idaho.

Then the biochars were mixed into one type of sandy soil and two silt loam soils at the rate of about 20 tons per acre. The test soils were leached with water every month.

After 4 months, the team found that biochars produced from switchgrass and hardwoods increased soil moisture storage in all three soils, but biochar made from the other biomass sources did not. They saw the greatest moisture increase in soils amended with switchgrass biochar produced via high-temperature pyrolysis—almost 3 to 6 percent higher than a control soil sample. Biochars produced at higher temperatures also decreased soil acidity, and biochar made from poultry litter greatly increased soil levels of available phosphorus and sodium.

Results also indicated that switchgrass biochar amendments could extend the window of soil water availability by 1.0 to 3.6 days for a soybean crop in Florence and could increase soil water availability for crops grown in Pacific Northwest silt loam soils by 0.4 to 2.5 days.

These results support hopes that agricultural producers might someday select feedstocks and pyrolysis processes to make designer biochars with characteristics that target deficiencies in specific soil types.

Karamat Sistani, research leader at the Animal Waste Management Research Unit in Bowling Green, Kentucky, is part of the ARS biochar team. "In 2010 we started a field study on combining biochar with poultry manure to see how microorganisms and nutrients in the manure affect biochar efficiency in improving soil quality and corn yield," Sistani says. "We also want to see if it has any efficacy in mitigating greenhouse gas emissions of nitrous oxide, methane, and carbon dioxide."

The Bowling Green researchers will also be determining whether biochar amendments can help improve the nutrient-holding capacity of Kentucky limestone karst soils, which develop large cracks that allow water and fertilizers to move quickly through the subsoil. In addition, Bowling Green hydrologist Carl Bolster and research associate Sergio Abit are conducting a lab study to see whether biochar affects the movement of pathogens like *Escherichia coli* in the soil.

The Results Aren't All In Yet

In Kimberly, Idaho, Jim Ippolito and soil scientist Rick Lentz are studying how three different soil amendments—biochar, manure, or a biochar-manure combination—affect soil quality and crop response in the region's calcareous soils. During the first study year, biochar-amended soils showed no real improvement in nutrient levels, aside from an increase in manganese, which is an essential plant nutrient, and a slight increase in total organic carbon. Soils amended with manure also had increased levels of manganese and of other plant nutrients.

"Both manure and biochar applied alone increased soil manganese, but their combined effect was synergistic," Lentz says. "In plots where soil was amended with a biochar-manure mix, the total increase

in manganese was greater than what we would have obtained from just adding the manganese increase from biochar to the manganese increase from manure."

However, during 2010, fields amended with biochar had a 31-percent crop yield *decrease,* along with a 33-percent decrease in nitrogen uptake. Sulfur uptake in fields amended by biochar also decreased 7 percent.

"We think that the biochar is somehow inhibiting nitrogen and sulfur uptake, maybe by stabilizing the soil organic matter. This would reduce the mineralization rate of soil organic matter and decrease the availability of nitrogen and sulfur to the crop," Lentz says. "After biochar is added to soil, its chemical and physical characteristics will change with time, so its effect on soils and crops may change accordingly."

The third year of the study will help determine whether the 2010 results bear further investigation or were just a fluke. But the findings already demonstrate that biochar amendments might not always work the way farmers want them to work.

Greenhouse Gas Emissions and Ethylene

In Minnesota, ARS scientists are studying biochar activity in soils formed from glacial deposits. Soil scientists Kurt Spokas and John Baker, who both work in the ARS Soil and Water Management Research Unit in St. Paul, found that amending glacial soils with biochar made from macadamia nut shells reduced a range of greenhouse gas emissions.

The scientists conducted laboratory incubation studies by amending the glacial soils with biochar at levels from 2 to 60 percent. They found that emission levels of carbon dioxide and nitrous oxide were suppressed by all amendment levels, but the nitrous oxide suppression was notable only in soils amended with 20, 40, or 60 percent biochar. The amended soils also had lower microbial production of carbon dioxide and lower volatilization rates for the pesticides atrazine and acetochlor.

"Now we're looking at how volatile organic compounds, or VOCs, in biochar affect soil microbe activity," says Spokas. "Since biochar is a product of thermal-chemical conversion, it has the same VOCs that we find in smoke and soot, like benzene and toluene. We've already identified 200 different VOCs in some biochars, which is significant, because we want to use clean biochar for agricultural production."

Spokas and Baker also conducted the first study that documented the formation of ethylene—a key plant hormone that helps regulate growth—from biochar and soils amended with it. They found that ethylene production in biochar-amended non-sterile soil was double the level observed in biochar-amended sterile soil. This strongly suggests that soil microbes are active in this biochar-induced ethylene production and that the ethylene might be involved in plants' reaction to biochar additions, since even low ethylene concentrations produce various plant responses.

Cleaning Up With Biochar

ARS scientists have also spent years investigating the use of biochar for environmental remediation. Retired ARS chemist Wayne Marshall, who worked at the ARS Southern Regional Research Center in New Orleans, Louisiana, started pursuing this line

STEPHEN AUSMUS (D114-17)

In New Orleans, technician Renee Bigner places poultry litter pellets into a furnace to make biochar via slow pyrolysis.

of research in the 1990s. He and Lima found that charred poultry litter is especially adept at removing hard-to-capture heavy metals like copper, cadmium, and zinc from wastewater. They produced pellets, granules, and powders made from the char for use in water tanks, columns, and other filtering structures.

The New Orleans scientists also developed a method for making carbons that have increased surface area for adsorption or chemical reactions. They did this by pelletizing ground poultry litter and then heating the pellets at high temperatures via slow pyrolysis to produce steam-activated char. ARS was issued two patents on the process, which Lima says could be used to replace traditional activated carbon adsorbents in air or liquid-waste cleanup applications.

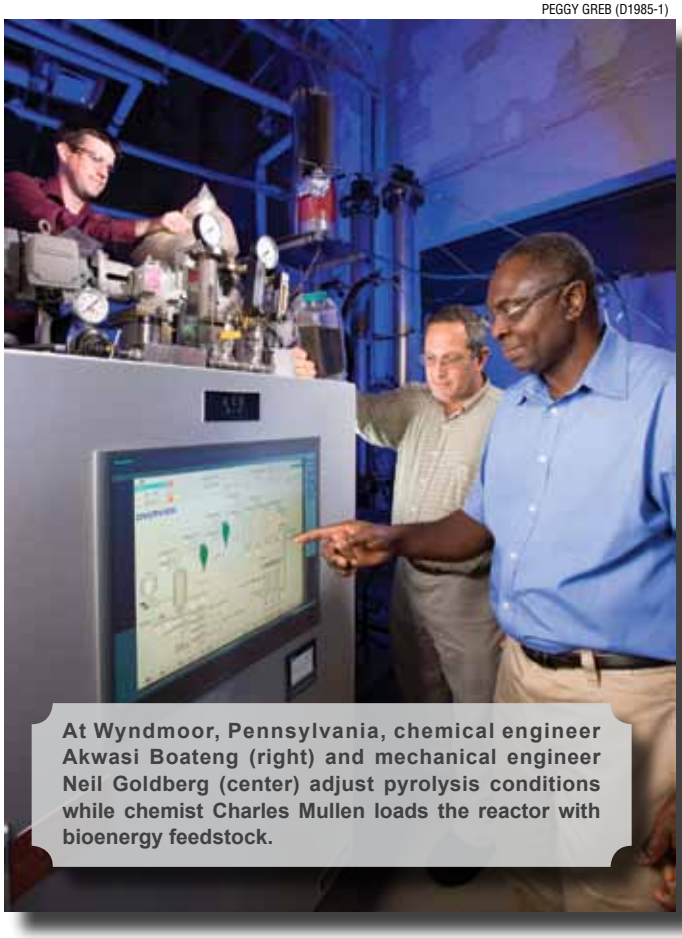
Since 2006, chemical engineer Akwasi Boateng, who works at the ARS Sustainable Biofuels and Co-Products Research Unit in Wyndmoor, Pennsylvania, has helped lead ARS studies of biochar production via fast pyrolysis. Other Wyndmoor scientists contributing to these projects include research leader Kevin Hicks, chemist Charles Mullen, and mechanical engineer Neil Goldberg.

"We use fast pyrolysis when we produce bio-oil from biofeedstock to maximize fuel production, but this process produces a biochar byproduct that has a lower surface area," says Boateng. "We'd like to improve the biofuel production process so that it also yields biochar that has a high surface area. This would make it more structurally suited to use as an activated charcoal and as a soil amendment. Identifying this kind of process could help make the biochar use in soils economical."

As part of this effort, Boateng and Lima worked with other scientists in Wyndmoor and New Orleans to see whether steam activation would increase the ability of fast-pyrolysis biochars to adsorb toxic metals. They found that biochars made from broiler litter and alfalfa stems had the highest pollutant-uptake levels.

ARS microbiologist Hal Collins, who works at the Vegetable and Forage Crop Research Unit in Prosser, Washington, is exploring similar territory by evaluating the production of bio-oil and biochar from waste materials like wheat straw, logging debris, and manure. "There are a lot of concentrated animal-production facilities in the Pacific Northwest, and there's not a lot of room available to store manure," says Collins. "Nutrient runoff from these sites can potentially pollute nearby water sources, so using the manure to produce bio-oil and biochar could be one mechanism for controlling nutrients at dairy facilities."

PEGGY GREB (D1985-1)



At Wyndmoor, Pennsylvania, chemical engineer Akwasi Boateng (right) and mechanical engineer Neil Goldberg (center) adjust pyrolysis conditions while chemist Charles Mullen loads the reactor with bioenergy feedstock.

In one test, Collins made biochar from plant fibers remaining after processing dairy manure through an anaerobic digester used to capture methane from manure. He used that biochar to adsorb phosphorus present in the digester effluent. He found that the biochar removed 32 percent of the phosphorus from the effluent, and when the biochar was used as fertilizer, 13 percent of the adsorbed phosphorus was immediately available for plant uptake.

Given these results, Collins believes that biochars could help mitigate nutrient runoff but agrees that much more work is needed on the potential benefits and drawbacks. "Using this biochar to fertilize fields is not like using phosphorus fertilizer," he says. "We can add 200 pounds of fertilizer per acre to support plant growth, but we'd need to add 2 to 3 tons of the biochar to add the same amount of phosphorus to the soil."

Looking to the Literature

Spokas, Novak, and others conducted a meta-analysis of approximately 100 biochar studies and concluded that because of variability in char quality and application, results were about 25 percent negative, around 50 percent neutral, and around 25 percent positive. They published their findings in the *Journal of Environmental Quality.*

"A lot of research has already been done on biochar," says Spokas, who is the first author on the paper. "We're building on that work to figure out how to make biochar work best in our current production systems."

Novak, who is working with Ippolito and Spokas on additional experiments in the laboratory and field, agrees. "We just need to make sure it's the right biochar for the right soil type," he says.

"We're still trying to get our hands around this," Karlen concurs. "We're very curious. But we don't have all the answers yet."—By **Ann Perry,** ARS.

This research is part of Climate Change, Soils, and Emissions (#212) and Water Availability and Watershed Management (#211), two ARS national programs described at www.nps.ars.usda.gov.

To reach scientists mentioned in this story, contact Ann Perry, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1628, ann.perry@ars.usda.gov.

Understanding Herbicide Resistance of an Enzyme in the "Pigments of Life"

STEPHEN AUSMUS (D2542-8)

At the ARS Natural Products Utilization Research Unit in Oxford, Mississippi, support scientist Susan Watson extracts a sample of pigments from leaf tissue for high-performance liquid chromatography analysis by plant physiologist Franck Dayan.

An Agricultural Research Service scientist in Oxford, Mississippi, is working toward developing new herbicides by focusing on a molecular pathway that not only controls weeds in soybean fields, but might also have helped shape our nation's history.

Franck Dayan, a plant physiologist with the ARS Natural Products Utilization Research Unit in Oxford, is an expert on a class of weed killers known as "PPO herbicides," which choke off the weed's ability to make chlorophyll. His efforts are increasingly important because weeds are beginning to develop resistance to glyphosate, the world's most widely used herbicide, and alternatives are needed.

Much of Dayan's work focuses on a class of ring-shaped pigment molecules known as porphyrins (pronounced *POR-fer-ins*) that "bind" or react with different metals and perform vital functions in both plants and animals. Chlorophyll is a porphyrin that binds magnesium, giving plants their green pigment and playing a pivotal role in photosynthesis. Heme is a porphyrin that binds iron as an essential step in supplying oxygen to animal blood cells.

One of the key steps in porphyrin synthesis is performed by an enzyme (protoporphyrinogen oxidase, or PPO), and its disruption can cause problems in plants and animals. In humans, disruption of the PPO enzyme is associated with a congenital disease known as "porphyria," with symptoms that may include light sensitivity, seizures, and neuropsychiatric problems. Scholars have argued that a case of porphyria in King George III may have contributed to the colonies' struggle for independence. (See sidebar.)

In plants, PPO herbicides work by disrupting the enzyme's production of porphyrins, causing harm to the plant. PPO herbicides have been around for almost 40 years and are specifically designed so that they only disrupt PPO enzyme activity in plants and not in humans. "With these herbicides, we are able to intentionally and specifically disrupt plant PPO enzyme activity and do it in a way that cannot possibly have any effect on enzyme activity in humans," Dayan says.

STEPHEN AUSMUS (D2544-3)

Franck Dayan observes wild-type and herbicide-resistant biotypes of pigweed (Palmer Amaranth) as Mississippi State University graduate student Daniela Ribeiro collects plant samples for DNA analysis.

Dayan recently published a report on the molecular mechanism that can trigger resistance to PPO herbicides in a common weed. Understanding the resistance mechanism should lead to better herbicides.

Working in the Weeds

Since the mid-1990s, glyphosate use in crop fields has been so successful that interest in research and development of alternative weed killers had been on the wane. Many experts considered it too difficult to come up with an herbicide that could match glyphosate for cost and effectiveness, Dayan says. But with weeds developing resistance to glyphosate, interest in PPO herbicides is picking up. Herbicides have also become essential tools in modern agriculture, increasing the ability to control weeds to a point where growers are better able to adopt environmentally friendly practices, such as no-till cropping systems.

"Glyphosate still plays a dominant role in weed control in soybeans and other crops, but with glyphosate resistance, there is renewed interest in herbicides that inhibit the PPO enzyme," Dayan says.

Scientists recently showed that waterhemp *(Amaranthus tuberculatus),* a common weed, developed resistance to PPO herbicides by deleting an amino acid known as "glycine 210" from the PPO enzyme. Such an evolutionary mechanism is unusual. Enzymes and proteins are made up of amino acids, but when a plant develops resistance to a weed killer, it is usually because one amino acid in an enzyme is substituted for another—not deleted. "This was the first time that resistance caused by a deletion was ever seen," Dayan says.

Dayan examined the consequences of this amino acid deletion on the PPO enzyme by conducting protein-modeling studies of waterhemp. "The question was, How did the deletion of this amino acid allow the plant to become resistant?" says Dayan.

To find the answer, he and his colleagues overlaid the genetic sequence of the enzyme in the resistant waterhemp plants on the genetic sequence of a related enzyme that has a known structure, in this case, the PPO enzyme from tobacco plants. They also compared the molecular structure of enzymes from PPO-susceptible waterhemp to the structure of enzymes from resistant waterhemp. Using that information, they developed a computer-generated, three-dimensional version of the enzyme in the resistant plant.

The work, published in the journal *Biochimica et Biophysica Acta,* confirmed that an evolutionary change in a single enzyme—the deletion of an amino acid—caused structural changes in the enzyme-binding site and allowed waterhemp to become resistant to the herbicide. While the structural changes were too insignificant to affect most of the plant's physiological functions, they did disrupt the PPO enzyme production of porphyrins and caused the enzyme-binding site to become enlarged so that the herbicide did not bind as well.

"The place where the herbicide binds on the enzyme is a key," Dayan says. Knowing the shape of the binding site will help scientists design herbicides with a different shape that would bind more effectively.

Understanding porphyrins has a practical benefit because of their role in the development of herbicides. But the ubiquitous presence of these ring-shaped molecules, Dayan says, serves as an example of the unified nature of life on Earth. In an article coauthored with his daughter, Emilie Dayan, and published in the May-June 2011 issue of *American Scientist,* he writes, "They attract little attention, but you find them throughout the plant and the animal kingdom, and life couldn't exist without them."—By **Dennis O'Brien,** ARS.

This research supports the USDA priority of promoting international food security and is part of Crop Protection and Quarantine (#304), an ARS national program described at www.nps.ars.usda.gov.

Franck Dayan is in the USDA-ARS Natural Products Utilization Research Unit, Room 2012, University of Mississippi, Oxford, MS 38677; (662) 915-1039, franck.dayan@ars.usda.gov.

King George's Porphyrin Problem

Disruption of the PPO enzyme in humans is rare but is known to cause porphyria, a group of congenital diseases that in one form, known as "variegate porphyria," can cause symptoms that include temporary paralysis of limbs, sensitivity to light, seizures, hallucinations, and other neuropsychiatric problems. Symptoms can appear intermittently throughout someone's life.

Agricultural Research Service plant physiologist Franck Dayan notes in *American Scientist* that porphyrins form pathways that "serve as the assembly line for the most abundant pigments in nature." Because pigments are involved, people with porphyria may also excrete purplish tint in the urine and feces.

Dayan recounts how several experts have found historical evidence that King George III, monarch of England from 1760 until his death in 1820, had the disease, periodically suffering from abdominal pains, paralysis of the arms and legs, wine-colored urine, and psychiatric problems that eventually forced him into confinement. Some experts have argued that the American Revolution may be partially attributed to the king's illness because it contributed to his stubbornness in dealing with the colonies.

The king's illness was portrayed in the 1994 film, "The Madness of King George."

Chicken House Attics Can Be Tapped To Warm Broilers

Chickens like to stay warm, but insulating, ventilating, and heating their houses can be expensive, especially when fuel prices are high. Fortunately, new technology developed by scientists at the ARS Poultry Research Unit in Mississippi State, Mississippi, and colleagues at Mississippi State University (MSU) could help reduce those costs.

"Energy costs are far and away the largest financial inputs for producers," says ARS agricultural engineer Joseph Purswell, who led the study. "Reducing energy costs means increasing profitability."

Most broiler houses have attics, and the scientists found the air that gathers there can be as much as 20°F warmer than the air outside. The attic air is at least 5°F warmer about 70 percent of the time.

Purswell worked with MSU professor Berry Lott, now retired, to develop a ventilation system that uses ceiling inlets to redistribute solar-heated attic air, as opposed to bringing in cooler, outside air. Starting in 2006, Purswell and Lott gathered data from a Mississippi chicken producer who installed several broiler houses based on their design.

The scientists concluded that circulating the warmer attic air within the chicken houses reduced the demand for heating fuel by about 20 to 25 percent. In one study in mild weather conditions, the technology reduced fuel use by 35 percent.

Similar technology has been applied to swine and layer facilities, but this is the first research to examine whether the technology works with broiler houses, which have a significantly different construction.

Commercial interest in the technology has increased with rising fuel prices over the past 3 years, Purswell says. "Now producers throughout the broiler belt are requesting information on how to take advantage of this technology."

The ventilation system has benefits beyond reducing fuel use. Attic ventilation also reduces moisture and ammonia within the houses, which helps improve air quality.—By **Laura McGinnis,** formerly with ARS.

Joseph L. Purswell is in the USDA-ARS Poultry Research Unit, 606 Spring St., Mississippi State, MS 39762; (662) 320-7480, joseph.purswell@ars.usda.gov. ✷

New Soybeans With Seed Rot Resistance Identified

The fungus *Phomopsis longicolla* is largely to blame for a disease called *Phomopsis* seed decay (PSD) that has claimed more than 5 million bushels of U.S. soybeans each of the past 5 years. The seed disease is most problematic in midwestern and southern states.

Control strategies used by farmers have been inconsistent. These include rotating soybeans with corn or wheat (nonlegume crops on which the fungus can't grow), treating seed with fungicides, and tilling the soil to disrupt spore dissemination. The ideal defense is to plant resistant varieties.

To that end, Agricultural Research Service plant pathologist Shuxian Li is coordinating a 3-year project out of Stoneville, Mississippi, to screen for PSD resistance in hundreds of soybean germplasm accessions, breeding lines, and commercial cultivars collected from around the world. "Resistant varieties can provide protection for soybean producers at no additional cost beyond the price of planting the seed," notes Li, in ARS's Crop Genetics Research Unit.

Her efforts to identify resistant sources kicked into high gear in April 2009 following a grant from the United Soybean Board (USB). Li's collaborators on the project are Pengyin Chen and John Rupe, professors at the University of Arkansas in Fayetteville, and Allen Wrather, a professor at the University of Missouri in Portageville.

The USB grant expands on prior field trials the team had conducted since May 2007 in Mississippi and Arkansas that identified several promising PSD-resistant soybean lines from commercial varieties provided by Mississippi State University collaborators and plant introductions from the USDA Germplasm Collection. Typically, the resistant lines identified from this research showed little or no incidence of PSD and had a high germination rate with strong vigor. Additional screening using local strains of *P. longicolla* will also be conducted on soybeans from other sources (including 28 countries).

To expedite their research, Li is developing new and fast screening methods to identify sources of PSD resistance and map resistance genes. The team is also identifying DNA markers associated with the expression of these resistance genes in mapping populations of offspring plants derived from cross-breeding.

Once the markers have been validated, the team will make them publicly available for use in marker-assisted selection, an approach that will save soybean breeders considerable time and expense in developing elite commercial cultivars for growers.—By **Jan Suszkiw,** ARS.

Shuxian Li is in the USDA-ARS Crop Genetics Research Unit, 141 Experiment Station Rd., Stoneville, MS 38776; (662) 686-3061, shuxian.li@ars.usda.gov. ✻

Also of Interest

Collection Provides Supply for "Taxonomical Rescues"

The Agricultural Research Service (ARS) maintains some of the world's largest publicly accessible collections of microbes that are used to benefit agricultural sciences. But some smaller ARS collections are critical to the day-to-day work of career scientists working at specific locations. Such is the case of the Fungal Culture Collection housed at the ARS Southern Regional Research Center (SRRC) in New Orleans, La.

For nearly 30 years, the collection's 1,700 strains have been curated by taxonomist Maren Klich. She chose a method of preserving the collection that essentially is the closest thing to putting microbes into suspended animation. That strategy came in handy when widespread mold species needed to be identified after Hurricane Katrina.

To preserve various fungi over time, Klich and colleagues actually "freeze-dry" tiny amounts of a fungal species.

In a small vacuum tube, water is removed from previously frozen fungi. That "suspends" the life of the live organism because the fungi can stay in that condition for upwards of 40 or 50 years. The resulting white pellets can be resuspended at any time by simply immersing the pellet in a liquid and placing the suspension on a petri dish containing agar. When the mold grows out, it comes back to life, according to Klich.

Another way the team could have chosen to preserve the live collection was to freeze them in liquid nitrogen. But the entire collection would have been lost during Hurricane Katrina if that method had been used, because the liquid nitrogen would have melted over time in the long-evacuated building.

Upon return to the SRRC after the natural disaster, Klich found the collection safe and sound. She then turned her attention to helping other agencies identify potentially dangerous mold species that occurred as a result of the water damage from the storm.

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture.

Chicken House Attics Can be Tapped to Warm Broilers

Reducing the cost of keeping broiler chickens warm could result from research by Agricultural Research Service (ARS) scientists and university cooperators.

Insulating, ventilating and heating broiler chicken houses can be expensive, especially when fuel prices are high, according to study leader Joseph Purswell, an agricultural engineer at the ARS Poultry Research Unit in Mississippi State, Miss. He worked with Barry Lott, a retired professor at Mississippi State University, to investigate ways to reduce the energy costs of heating chicken houses, thus increasing profits for producers.

They found that the air that gathers in broiler house attics can be as much as 20 degrees Fahrenheit warmer than the air outside. The attic air is at least 5 degrees F warmer about 70 percent of the time.

Purswell and Lott developed a ventilation system that uses ceiling inlets to redistribute solar-heated attic air, as opposed to bringing in cooler, outside air. They began gathering data in 2006 from a Mississippi chicken producer who installed several broiler houses based on their design.

The scientists concluded that circulating the warmer attic air within the chicken houses reduced the demand for heating fuel by about 20 to 25 percent. In one

study in mild weather conditions, the technology reduced fuel use by 35 percent.

Similar technology has been applied to swine and layer facilities, but this is the first research to examine whether the technology works with broiler houses, which have a significantly different construction.

Commercial interest in the technology has increased with rising fuel prices over the past several years, according to Purswell. That has prompted producers throughout the broiler belt to request information on how to take advantage of the technology.

The ventilation system also reduces moisture and ammonia inside the houses, improving air quality.

ARS is the principal intramural scientific research agency in the U.S. Department of Agriculture.

Hops Helps Reduce Ammonia Produced by Cattle

An Agricultural Research Service (ARS) scientist may have found a way to cut the amount of ammonia produced by cattle. To do it, he's using a key ingredient of the brewer's art: hops.

Cattle, deer, sheep, goats and other ruminant animals depend on a slew of naturally occurring bacteria to aid digestion of grass and other fibrous plants in the first of their four stomach chambers, known as the rumen.

The problem, according to ARS microbiologist Michael Flythe, comes from one group of bacteria, known as hyper-ammonia-producing bacteria, or HABs. While other bacteria are helping their bovine hosts convert plant fibers to cud, HABs are breaking down amino acids, a chemical process that produces ammonia and robs the animals of the amino acids they need to build muscle tissue, according to Flythe, who works at the ARS Forage Animal Production Research Unit (FAPRU) in Lexington, Ky.

To make up for lost amino acids, cattle growers have to add expensive and inefficient high-protein supplements to their animals' feed.

According to Flythe, hops can reduce HAB populations. Hops, a natural preservative, were originally added to beer to limit bacterial growth.

Flythe put either dried hops flowers or hops extracts in either cultures of pure HAB or a bacterial mix collected from a live cow's rumen. Both the hops flowers and the extracts inhibited HAB growth and ammonia production.

Flythe and FAPRU plant physiologist Isabelle Kagan have completed a similar project with more typical forage. They recently identified a compound in red clover that inhibits HAB. Results of that study were published recently in *Current Microbiology.*

Flythe also collaborated with FAPRU animal scientist Glen Aiken on a study in which hops had a positive effect on the rumen's volatile fatty acid ratios, which are important to ruminant nutrition.

ARS is the primary scientific research agency of the U.S. Department of Agriculture (USDA). This research supports the USDA priority of promoting international food security.

Capturing the True Value of Rice

Appreciation for rice continues to grow as the U.S. population diversifies. Now, a series of rice utilization workshops—cosponsored by Agricultural Research Service (ARS) and USA Rice Federation collaborators—have led to a better understanding of the health benefits of the satisfying grains.

Also of Interest

Heightened emphasis on daily whole-grain consumption in the 2005 Dietary Guidelines for Americans inspired one of the workshops. A plan of action was developed during that workshop in 2007, which led to the rice industry qualifying to use the whole grain health claim for the first time on brown rice packages starting in 2008.

Research leader Elaine Champagne, with the ARS Food Processing and Sensory Quality Research Unit (FPSQ) in New Orleans, La., co-sponsored the workshops.

According to MyPyramid.gov, an interactive tool based on the 2005 Dietary Guidelines for Americans, the amount of grains people require depends on their caloric needs, which varies by age, sex, and physical activity.

MyPyramid.gov encourages males and females aged 9 through 50 and older to consume three "ounce equivalents" of whole grain foods daily. Within the grains food group, one "ounce equivalent" for whole grain rice would be one-half cup of cooked brown rice.

Another plus is that busy consumers no longer have to wait the traditional 50 minutes it takes to cook brown rice. ARS food technologist Harmeet Guraya, also with the FPSQ, developed a patented brown rice treatment that significantly reduces brown rice's long cooking time to 20 minutes—the cooking time of white rice.

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture.

A New Approach that Saves Eyesight and Lives in the Developing World

Two Agricultural Research Service (ARS) scientists are part of an international team that has found a way to boost the nutritional value of corn. This has the potential to reduce the number of children in developing countries who lose their eyesight, become ill or die each year because of vitamin A deficiencies.

Corn contains carotenoids, some of which the body can convert to vitamin A. Beta-carotene is the best vitamin A precursor, but only a very small percentage of corn varieties have naturally high beta-carotene levels. In Africa and other developing regions, corn is a major staple and hundreds of thousands of children become blind, develop weakened immune systems and die because of diets based largely on corn that lacks sufficient beta-carotene.

Marilyn Warburton, a geneticist with the ARS Corn Host Plant Resistance Research Unit in Starkville, Miss.; Edward Buckler, a geneticist in the ARS Robert W. Holley Center for Agriculture and Health in Ithaca, N.Y., and their colleagues published results identifying genetic sequences linked to higher beta-carotene levels in corn and demonstrating an inexpensive and fast way to identify corn plants that will produce even higher levels. The report, recently published in Nature Genetics, is considered a breakthrough in nutritional plant breeding.

The project was funded in part by the National Science Foundation and included major scientific contributions from Torbert Rocheford of Purdue University and Jianbing Yan of the International Maize and Wheat Improvement Center in Mexico.

In their study, the researchers surveyed the genetic sequences of corn from around the world through association mapping, a method made possible by recent breakthroughs that accelerate the genetic profiling of crops.

The genetic survey revealed natural variations in one gene sequence linked to higher beta-carotene levels. These variations interacted with a gene identified previously, and the best variations of the two genes

together led to an 18-fold increase in beta-carotene, according to Warburton. The mapping survey identified molecular markers that breeders can use to incorporate the desired gene variants into corn for the developing world. Warburton and Yan are now working with breeders oversees to train them on use of the new techniques.

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture (USDA). This research supports the USDA priority of promoting international food security.

Seeds of Aflatoxin-Resistant Corn Lines Available

Six new corn inbred lines with resistance to aflatoxin contamination have been found to be free of seed-borne diseases foreign to the United States, and seeds of these lines are now available in the United States for further development toward commercialization. Agricultural Research Service (ARS) plant pathologist Robert Brown, working in collaboration with Abebe Menkir at the International Institute of Tropical Agriculture in Ibadan, Nigeria, developed the lines. Brown works at the Food and Feed Safety Research Unit in the ARS Southern Regional Research Center in New Orleans, La. The six inbred lines have been dubbed TZAR101, 102, 103, 104, 105, and 106.

Aflatoxins are cancer-causing toxins produced by the fungus Aspergillus flavus after it infects agricultural commodities such as corn. A. flavus fungi are found in soil, on crops and in air. Contamination of corn with aflatoxins is a potential health hazard to animals and humans, and causes financial losses for growers. Crop resistance has become a widely explored strategy to eliminate aflatoxins in corn because of the large amount of genetic diversity in this crop.

ARS plant geneticist Mark Millard in Ames, Iowa, arranged a quarantined growout of the seeds at the ARS station on the island of St. Croix, U.S. Virgin Islands. After quarantined seed was imported into St. Croix and planted, resulting plants and ears were inspected to ensure they were free of any foreign seed-borne diseases. This "certified" seed then was shipped to Ames, Iowa, processed, and stored in the ARS collection.

The seed can be obtained and planted in the United States for further evaluation for resistance to aflatoxin. Seed samples of these and other lines can be obtained from the ARS North Central Regional Plant Introduction Station in Ames.

Data from further evaluations will provide insight as to the value of these lines in breeding for resistance to aflatoxin. ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture (USDA). This research supports the USDA priority of ensuring food safety.

ARS Scientists Honored for Technology Transfer Efforts

The Agricultural Research Service (ARS) will recognize some of its most innovative scientists and research partners at the agency's Technology Transfer Awards Program here today. These awards recognize individuals or groups who have done outstanding work in transferring technology to users outside ARS, the principal intramural scientific research agency of the U.S. Department of Agriculture.

"ARS places great importance on making sure that our findings don't just languish in the laboratory, but are translated into useful products that benefit consumers," said Edward B. Knipling, ARS administrator. "The winners of this year's technology transfer awards represent outstanding examples of that commitment in the areas of animal health, natural resources management, food product development, and food safety."

Also of Interest

Top honors for outstanding technology transfer will be presented to two ARS research teams:

- Five ARS scientists are being recognized for their development of an energy-efficient, environmentally friendly, and profitable livestock manure treatment system. This team includes Matias B. Vanotti, Ariel A. Szogi, and Patrick G. Hunt, who work at the ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, S.C.; Patricia D. Millner, who works at the ARS Environmental Microbial and Food Safety Laboratory in Beltsville, Md., and John H. Loughrin, who works at the ARS Animal Waste Management Research Unit in Bowling Green, Ky.

- Two ARS scientists and their research partner are being recognized for technology transfer to countless laboratories worldwide that use the QuEChERS—Quick, Easy, Cheap, Effective, Rugged and Safe—approach to monitor pesticides and other residues in foods. This team includes Steven Lehotay and Katerina Mastovska, ARS Eastern Regional Research Center, Wyndmoor, Pa.; and Michelangelo Anastassiades, Stuttgart, Germany.

Awards honoring superior efforts in technology transfer will be presented to:

- George E. Inglett, ARS Functional Foods Research Unit, Peoria, Ill., for outstanding accomplishments in the invention and technology transfer of the multi-functional food ingredient Z-Trim, which contributes to healthier foods for people around the world.

- Anna Myers McClung, ARS Dale Bumpers National Rice Research Center, Stuttgart, Ark., for the development of eight rice varieties resulting in new and improved processed foods, the capture of value-added markets, and expansion of the organic rice industry.

- Chad Finn, ARS Horticultural Crops Research Unit, Corvallis, Ore., for the development and transfer of new berry varieties.

- The Industrial Microwave System Technology Team, a partnership between ARS, North Carolina State University, and Industrial Microwave Systems, which developed and transferred a novel continuous flow microwave heating process for producing large containers of aseptic, shelf-stable vegetable and fruit purees. The team includes Van Den Truong, ARS Food Science Research Unit, Raleigh, N.C.; Josip Simunovic, Ken Swartzel, K.P. Sandeep, Pablo Coronel, Gary Cartwright, Prabhat Kumar, and Laurie Steed, North Carolina State University, Raleigh; and David Parrott, Industrial Microwave Systems, Morrisville, N.C.

- The Rift Valley Fever Outbreak Early-Warning Team, for outstanding effort and creativity in the development and transfer of a Rift Valley fever outbreak early-warning system to protect global agriculture and public health. The team includes Kenneth J. Linthicum and Seth C. Britch, ARS Center for Medical, Agricultural and Veterinary Entomology, Gainesville., Fla.; Asaph Anyamba, Jennifer Small, Edwin Pak, and Compton J. Tucker, National Aeronautics and Space Administration, Greenbelt, Md.; Jean-Paul Chretien, Department of Defense, Silver Spring, Md.; Ralph L. Erickson, Department of Defense, Washington, D.C.; David C. Schnabel and Jason H. Richardson, Department of Defense, Nairobi, Kenya; Allan Hightower and Robert Breiman, Centers for Disease Control and Prevention, Nairobi, Kenya; Stephane De La Rocque, Food and Agriculture Organization, Rome, Italy; and Pierre B. Formenty, World Health Organization, Geneva, Switzerland.

Also of Interest

ARS Announces Scientist of the Year, Other Staff Awards

Laboratory Director Donald L. Suarez of Riverside, Calif., has been named "Distinguished Senior Research Scientist of 2009" by the Agricultural Research Service (ARS) for his scientific leadership and discoveries in effective water resource management. ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture (USDA).

Suarez heads the U.S. Salinity Laboratory in Riverside. He and other ARS researchers and support staff are being honored today at the agency's awards ceremony here.

"Water scarcity will be a defining issue in 21st century agriculture—and in society in general," said Edward B. Knipling, ARS administrator. "Dr. Suarez's outstanding research on helping farmers efficiently utilize scarce water resources benefits not only the farmers themselves, but also consumers, communities and businesses. The research under way at our Riverside lab under Dr. Suarez's leadership will help sustain agricultural production in arid regions of the West and inform our approach to water management across the United States and abroad."

Suarez's research on water resources has yielded key information about how the strawberry, grape and turf industries can reuse water for irrigation while maintaining favorable soil chemical and physical properties for sustained production. His work has greatly advanced the understanding of the relationship between water chemistry and soil hydraulic properties. In addition, he has assessed how different irrigation regimes can enhance soil productivity and helped develop computer models that can be used by water districts and irrigation consultants to make informed decisions about salinity management.

ARS also will recognize the following "Area Senior Research Scientists" today:

William P. Kustas, ARS Hydrology and Remote Sensing Laboratory, Beltsville, Md, for pioneering research in the theory and application of remote sensing and soil-plant- atmosphere modeling related to hydrological and agricultural problems.

Anna Meyers McClung, ARS Dale Bumpers National Rice Research Unit, Stuttgart, Ark., for outstanding research and leadership accomplishments in genetic improvement and protection of rice through innovative development, adaptation, and implementation of molecular marker-assisted breeding technologies.

Jack A. Morgan, ARS Rangeland Resources Research Unit, Fort Collins, Colo., for scientific contributions to global change research and dedication to the development of a unit research team where everyone can participate and succeed.

Agnes M. Rimando, ARS Natural Products Utilization Research Unit, University, Miss., for research on stilbenes that positively impacted the blueberry industry and provided the basis for using these compounds to benefit human health.

Randy C. Shoemaker, ARS Corn Insects and Crop Genetics Research Unit, Ames, Iowa, for outstanding research in soybean genetics and genomics.

Michael Wisniewski, ARS Appalachian Fruit Research Station, Kearneysville, W. Va., for sustained research productivity, leadership and impact in the management of biotic and abiotic stress in fruit crops.

Bruce W. Wood, ARS Robert W. Holley Center for Agriculture and Health, Byron, Ga., for excellence in pecan production and protection research and advancing mineral nutrition management of crops.

Also of Interest

ARS also is recognizing exceptional "early career" scientists who have been with the agency for seven years or less.

The top prize, the Herbert L. Rothbart Outstanding Early Career Research Scientist Award, will be presented to Michael L. Looper, ARS Dale Bumpers Small Farms Research Center, Booneville, Ark., for the development of pioneering research that improves production efficiency, product quality and food safety for the American cattle industry.

Other "Area Early Career Research Scientist Award" winners for 2009 are:

Elizabeth A. Ainsworth, ARS Global Change and Photosynthesis Research Unit, Urbana, Ill., for significant contributions to understanding the impact of global change on crop physiology and production.

Dana Blumenthal, ARS Rangeland Resources Research Unit (RRRU), Fort Collins, Colo., for outstanding scientific contributions to invasion ecology and for teamwork with the RRRU and collaborators.

David H. Gent, ARS Forage Seed and Cereal Research Unit, Corvallis, Ore., for creativity and outstanding accomplishments in developing integrated pest management approaches to reduce the impact of diseases on crop productivity.

Mary J. Pantin-Jackwood, ARS Exotic and Emerging Avian Viral Diseases Research Unit, Athens, Ga., for demonstrating the critical role of domestic ducks in the control of avian influenza viruses and for the characterization and improved diagnostics of novel enteric viruses of poultry.

Kerry F. Pedley, ARS Foreign Disease-Weed Research Unit, Fort Detrick, Md., for research contributions in molecular diagnostics and genetic characterization of foreign plant pathogens, and demonstration of early career success in developing extramurally funded research programs.

Timothy A. Rinehart, ARS Southern Horticultural Laboratory, Poplarville, Miss., for research and technology transfer related to the application of molecular markers and DNA fingerprinting biotechnology to breeding woody landscape plants.

Manan Sharma, ARS Environmental Microbial and Food Safety Laboratory, Beltsville, Md., for developing innovative methods for detecting internalization of pathogens into leafy greens.

Other 2009 ARS award winners include the following:

- The ARS H1N1 Flu Virus Research Team, which includes Amy Vincent, Kelly Lager, Kay Faabert and Marcus Kehrli, ARS Virus and Prion Research Unit, Ames, Iowa; Erica Spackman and David Suarez, ARS Exotic and Emerging Avian Viral Diseases Research Unit, Athens, Ga.; and Cyril Gay and Steven Kappes, ARS Office of National Programs, Beltsville, Md., will receive the "Special Administrator's Award" for outstanding, rapid research support and technology development to assist USDA, cooperating agencies and the U.S. pork industry respond to the 2009 H1N1 pandemic flu threat.

- Brian Scheffler, ARS Genomics and Bioinformatics Research Unit, Stoneville, Miss., has received the ARS T.W. Edminster Award for his outstanding research proposal "Genetics and genomics of sweet potato and other specialty crops for improved quality and resistance to biotic and abiotic factors." The T.W. Edminster Award is given annually to the researcher who submits the highest-rated research proposal in the ARS Postdoctoral Research Associate Program.

- Zarnaz Nina Ahmad, National Agricultural Library (NAL), Beltsville, Md., will receive the Office Professional of the Year Award,

which recognizes the outstanding achievements and creative efforts of ARS office professionals. Ahmad received the award for outstanding performance and significant contributions to improve and streamline the operations at NAL's Collection Services Branch.

- The 2009 Excellence in Information Award is being presented to Joseph R. Makuch, NAL, Beltsville, Md.; Stuart Gagnon, University of Maryland, College Park, Md.; Cassandra Harper, formerly with Library Associates Companies, Inc., Rockville, Md.; Diane Doyle, Library Associates Companies., Inc., Rockville, Md.; and Charles Rewa, Natural Resources Conservation Service, Beltsville, Md. The team will receive this award for outstanding contributions in leading NAL's efforts in meeting the scientific information needs of USDA's Conservation Effects Assessment Project.

Several 2009 Administrator's Outreach, Diversity, and Equal Opportunity Awards also will be presented to ARS staff. These awards identify and recognize ARS employees for exemplary achievements in promoting equal employment opportunity and civil rights and in fostering an awareness of and commitment to workforce diversity through actions that clearly exceed the responsibilities of their positions or assignments in ARS.

- Gwyn Watson, ARS Western Regional Research Center (WRRC), Albany, Calif., will receive the Supervisory/Managerial Category award for consistent and exemplary contributions realizing the objectives of outreach, diversity, and equal opportunity for the Pacific West Area at WRRC.

- The Beltsville Area Diversity Taskforce, Beltsville, Md., will receive the Non-Supervisory/ Non-Managerial Category award for the establishment of a Best Hiring Practices document that will promote the hiring of a diverse workforce in the Beltsville Area. Taskforce members include Jenny Allen, David Baer, Edith Blackwell, Julia Cabrera-Woscek, Eton Codling, Erin Connor, Eilyn Fabregas, Verneta Gaskins, Mary Ann Guaragna, Kathleen Haynes, Theresa Henderson, Swati Mookherji, Savi Natarajan, Xiangwu Nou, Janet Novotny, Alvin Nowverl, Eunhee Park, Talo Pastor-Corrales, Ali Sadeghi, Tom Sexton, Manan Sharma, Martha Tomecek, and Aijun Zhang.

- The agency's Administrative and Financial Management (AFM) Support Awards for Excellence recognize the outstanding achievements of employees who have increased efficiency in the AFM support activities of USDA's Research, Education, and Economics agencies.

- The 2009 AFM Gold Award for Excellence will be presented to Myles H. Taniguchi, U.S. Pacific Basin Agricultural Research Center, Hilo, Hawaii, for outstanding achievements as administrative officer at the Hilo location in coordinating the center's construction, research unit consolidation, and implementation of overall improvements to the location's administrative office.

- The 2009 AFM Silver Award for Excellence will be presented to Patrick G. Barry, AFM, Beltsville, Md., for outstanding leadership and vision throughout implementation of the design and construction program supporting the ARS portion of the American Recovery and Revitalization Act.

- The 2009 AFM Bronze Award for Excellence will be presented to the ARS Information Technology Wiki Development Team for outstanding support to ARS in the conception and development of a web-based information repository (Wiki) to be utilized by the ARS information technology community. Team

members include Paula Snell, Peoria, Ill.; Daniel Stieneke, Kimberly, Idaho; Joy McDaniel, Beltsville, Md.; Scott Finke, Beltsville, Md.; Andrea Miller, Peoria, Ill.; Stephanie Jobes, Riverside, Calif.; and C. Gwen Pentecost, Pullman, Wash.

- Michelyn Boyd, AFM, Beltsville, Md., will receive an AFM Support Award for Excellence for outstanding contributions to the successful implementation of WebTA and commitment to provide excellent customer service.

ARS Study Helps Farmers Make Best Use of Fertilizers

A new way to make topographic maps with radar can help farmers divert more of their resources to the highest-yielding parts of their fields, according to an Agricultural Research Service (ARS) scientist.

James McKinion, an electronics engineer at the ARS Genetics and Precision Agriculture Research Unit at Mississippi State, Miss., did the study with entomologist Jeff Willers and geneticist Johnie Jenkins at the ARS unit in Mississippi.

With the maps fed into computerized, variable-rate fertilizer applicators, precision farmers can divert more of their costly fertilizer to the highest-yielding zones and the least to the lowest-yielding zones. They can also use the zone maps to make other decisions, such as planting more drought-tolerant varieties in low-yield zones, or sowing less seed.

Five years of comparisons between these maps and actual "on-the-go" yield monitoring for cotton and corn on a farm in Mississippi showed that accurate yield predictions can be made based on topography.

The researchers contracted to have a plane with LIDAR (light detection and ranging) sensors fly over the 1,000 rolling acres of the farm. LIDAR is a form of radar that can map elevations digitally, showing slopes and sun exposures, by bouncing laser light off the landscape.

By blending yield results with the maps, the scientists divided fields into high-, medium-, and low-yield zones.

One advantage of LIDAR landscape mapping is that it only has to be done once.

LIDAR topographic mapping is spreading from state to state. Louisiana, for example, has financed LIDAR mapping of the entire state.

Otherwise, it is expensive for an individual farmer to pay for LIDAR mapping. So, McKinion is also looking for alternative topographic mapping techniques.

This research was published in *Computers and Electronics in Agriculture.*

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture (USDA). This research supports the USDA priority of promoting international food security.

Tapping into Sorghum's Weed Fighting Capabilities to Give Growers More Options

By unlocking the genetic secrets of sorghum, Agricultural Research Service (ARS) scientists have found a way to make one of the world's most important cereal crops a better option for growers. Researchers at the ARS Natural Products Utilization Unit in Oxford, Miss. also may have opened a door to reducing pesticide use in the production of other crops.

Also of Interest

Sorghum secretes a compound known as sorgoleone that is instrumental in helping the plant combat weeds. But in a way it does its job too well. Certain crops don't grow well in fields where sorghum has been raised, causing problems for growers who want to plant different crops on those fields.

The research team at Oxford included molecular biologist Scott Baerson, chemist Agnes Rimando, research leader Stephen O. Duke, plant physiologist Franck E. Dayan, molecular biologist Zhiqiang Pan, and plant physiologist Daniel Cook, who now works at the ARS Poisonous Plant Research Laboratory in Logan, Utah.

The team started with two pieces of evidence that helped them address the problem. Previous studies showed that sorgoleone is produced in the plant root hairs, and that a special type of enzyme within the plant plays a major role in sorgoleone production.

Using a strategy called sequence tagging, the scientists searched an established sorghum genome database for gene sequences associated with that class of enzymes. They found two gene sequences expressed in the plant root hair cells that produced the enzymes. When they silenced the two gene sequences, it dramatically reduced sorgoleone levels in the sorghum plants produced.

The results, published in *The Plant Cell,* could lead to sorghum lines without the soil toxicity problem, as well as lines with higher levels of sorgoleone that offer superior weed-fighting capabilities without posing environmental hazards. This discovery will enable researchers to look for similar gene sequences in other crops to increase their natural pest-fighting capabilities and reduce the need for pesticides. Baerson and his colleagues have already identified similar sequences in rice that are involved in production of defense-related enzymes.

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture (USDA). This research supports the USDA priority of promoting international food security.

Researchers Study Value of Chicken Litter in Cotton Production

Chicken litter is much more valuable as a fertilizer than previously thought, according to an Agricultural Research Service (ARS) study showing its newfound advantages over conventional fertilizers.

Litter is a mixture of chicken manure and sawdust or other bedding material. Some cotton farmers in the Mississippi area are switching to chicken litter and away from standard inorganic, synthetic fertilizers. Many other farmers are interested in the possible economic benefits of using chicken litter, but are reluctant to switch without the numbers to back up their decision.

Now a study by ARS agronomist Haile Tewolde at the agency's Genetics and Precision Agriculture Research Unit (GPARU) at Mississippi State, Miss., and cooperators has provided those numbers. Tewolde did the research with GPARU soil scientist Ardeshir Adeli, two Mississippi State University colleagues, and Karamat Sistani, research leader at the ARS Animal Waste Management Research Unit in Bowling Green, Ky.

Previous studies only considered the economic value of the nitrogen, phosphorus and potassium in chicken litter, compared to that in synthetic fertilizers. Farmers know that chicken litter, an organic fertilizer, is a better soil conditioner than synthetic fertilizers, but have never had a way to assign a number to the value of that benefit.

In their study, Tewolde and colleagues figured the litter's value as a soil conditioner as an extra $17 per ton of litter. They calculated this by balancing the price tag of the nutrients in litter with its

resulting higher yields, a reflection of its soil conditioning benefits.

They found that cotton yields peaked 12 percent higher with organic fertilizers, compared to peak yields with synthetic fertilizers. With all benefits factored in, they found that chicken litter has a value of about $78 a ton, compared to $61 a ton when figured by the traditional method.

The economic analyses also showed that farmers could further increase their profits by using less of either fertilizer than currently used for maximum yields—which is also good news for the environment.

This research was published in the *Agronomy Journal.*

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture.

Better Barriers Can Help Levees Withstand Wave Erosion

A new barrier design could protect reservoir levees from the erosive forces of wind-driven waves, according to studies by Agricultural Research Service (ARS) scientists and partners. These findings could help lower the maintenance costs for constructed ponds in the lower Mississippi Delta where levee repairs can average $3 per foot-and sometimes are needed just five years after a reservoir is built.

Hydraulic engineer Daniel Wren, who works at the ARS Watershed Physical Processes Research Unit in Oxford, Miss., partnered with ARS hydraulic engineer Carlos Alonso (now retired) and University of Mississippi research associate Yavuz Ozeren for his research. The team gathered data about wind and wave dynamics from a 70-acre irrigation reservoir in Arkansas. Then they took their data into the lab and designed several wave barriers that they tested in a 63-foot-long wave flume.

Their results indicated that a floating barrier held in place by two rows of pilings would provide the most effective embankment protection from wave action. Since the barrier was confined between the two rows of pilings, it could rise and fall with fluctuating water levels, unlike a barrier tethered to the bottom of the pond that might become submerged by rising water levels.

The team found that a two-pipe barrier was able to dissipate 75 percent of wave energy before the waves washed against the levees. The waves lost some of their force when they broke against the first tube and then lost even more energy as they broke against the second tube. The engineers also found that bundling several lengths of smaller tubing together to obtain an optimal diameter for the floating barrier was less expensive than purchasing one tube with a larger diameter.

Results from this research were published in the *Transactions of the American Society of Agricultural and Biological Engineers.*

ARS is the principal intramural scientific research agency of the U.S. Department of Agriculture.

Dairy Farmers Can Fight Johne's Disease Threat with Chlorine and Stainless Steel

Two tips for preventing Johne's disease on dairy farms: Use stainless steel water troughs and add chlorine to the water. That's according to Kim Cook, an Agricultural Research Service (ARS) microbiologist at the agency's Animal Waste Management Research Unit in Bowling Green, Ky. Cook did the research with Carl Bolster, a hydrologist at Bowling Green, and other colleagues.

Stainless steel troughs are expensive, but not as expensive as Johne's disease. Caused by the

bacterium Mycobacterium paratuberculosis, this disease can cause losses of as much as $200,000 per year in a herd of 1,000 dairy cows. The losses are mostly from a drop in milk production and the need to cull infected animals. A continued increase in the number of cases of Johne's disease among dairy cattle suggests that there may be unknown sources of contamination on farms.

Cook thought that water troughs would provide a perfect home for bacteria, so she counted the Mycobacteria in the slimy layers in water on the sides of the most commonly used troughs: concrete, plastic, stainless steel, and galvanized steel. She wanted to see if there were differences in the ability of the bacteria to adhere to and survive on the surfaces of the different materials. Cook found high concentrations of the bacteria on all troughs within three days of inoculating the water with the bacteria, and they survived for more than 149 days. But the bacterial survival rate was lowest on the stainless steel.

When she added 3 tablespoons of chlorine bleach per 100 gallons of trough water weekly, she found that, by the end of the third week, less than 1 percent of the bacteria remained on stainless and galvanized steel troughs. On the other hand, 20 percent remained on plastic and 34 percent remained on the concrete troughs.

The chlorine's disinfectant effects may have been weakened by the higher pH of concrete and by the tendency of plastic to absorb chlorine.

Based on these results, using stainless steel water troughs with chlorinated water should be one of the recommended practices included in any Johne's control plan, according to Cook.

This research was reported in the journals *Veterinary Microbiology* and *Bovine Practitioner.*

ARS is the principal intramural research agency of the U.S. Department of Agriculture (USDA). This research supports the USDA priority of promoting international food security.

Scientists Develop Sustainable, Environmentally Friendly Potting Medium

A new type of sustainable and environmentally friendly potting medium made from thinned pine trees has been created by U.S. Department of Agriculture (USDA) scientists and their university cooperators.

Nursery plants are now grown in containers filled with soil-less potting medium, formally called substrate, consisting of Canadian peat moss, perlite, vermiculite and pine bark. But obtaining these materials can be costly and time-consuming, due to required energy inputs and availability.

WholeTree is a new material that can be used alone or mixed with other materials to make substrate. It was created by horticulturist Glenn Fain, formerly with USDA's Agricultural Research Service (ARS) at the ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, Miss., and Charles Gilliam, a professor with Auburn University. They collaborated with research leader James Spiers and horticulturalist Anthony Witcher at the ARS Poplarville laboratory, and with Greg Young, owner of Young's Plant Farm in Auburn, Ala. ARS is the chief intramural scientific research agency of USDA.

As its name suggests, WholeTree is made from all parts of a tree, in particular the southern pine tree (Pinus taeda). But the trees aren't cut down in natural forests. Instead, the trees used to make WholeTree are harvested from tree plantations at the thinning stage, when some trees are removed to achieve a density the site can support. Once processed, WholeTree can be used as an alternative substrate.

Similar products have been available in Europe for several years, but WholeTree could be one of the first available U.S. products made from locally grown materials. According to Fain, who is now an assistant professor at Auburn University, field and laboratory studies have demonstrated the successful use of WholeTree, even at 100 percent for some nursery plants.

The scientists are further researching WholeTree's suitability for use in cutting and seedling propagation of herbaceous perennial and woody ornamental crops. So far, they have conducted tests on plants popular to the ornamental and landscaping industries.

Corn Lines Resist Fungal Toxins

Corn germplasm lines developed by U.S. Department of Agriculture (USDA) scientists are scoring high marks in field trials for resistance to aflatoxin produced by *Aspergillus flavus* and *A. parasiticus* fungi.

According to geneticist Paul Williams with USDA's Agricultural Research Service (ARS) in Mississippi State, Miss., the presence of aflatoxin in corn greatly reduces its value and marketability. That's because aflatoxin is carcinogenic to humans, pets and wildlife. Annual losses incurred by the corn industry to aflatoxin contamination of kernels are estimated at $192 million.

At the ARS Corn Host Plant Resistance Research Unit in Mississippi State, Williams works with a multidisciplinary team of researchers and university cooperators to develop, test and release new corn lines that are genetically resistant to aflatoxin-producing fungi.

In 2008 field trials, for example, two germplasm lines that the team developed—Mp715 and Mp717—showed the highest levels yet of resistance to aflatoxin contamination. A more recent line, Mp04:097, also performed well in 2009 trials.

Mp715 and Mp717 are also resistant to the accumulation of another fungal toxin—fumonisin, which is produced by *Fusarium verticillioides*. The toxin causes neurological abnormalities in horses after they consume infected corn.

According to Williams, the lines have been widely requested and used in plant breeding programs at state, federal and international research institutions, plus three major commercial seed companies and several smaller ones.

In related work, the researchers are mapping chromosome regions associated with aflatoxin resistance in crosses between resistant lines and susceptible ones with good agronomic qualities. The goal is to identify markers that can be used in marker-assisted breeding.

On yet another front, the team has developed corn lines that resist fall armyworms and southwestern corn borers, insect pests whose feeding damage can contribute to aflatoxin contamination.

ARS is USDA's principal intramural scientific research agency. This research supports the USDA priority of ensuring food safety.

Future Soybean, Sorghum Growth Examined Under Higher Carbon Dioxide Levels

Crops responded positively to future levels of atmospheric carbon dioxide (CO2), but soil tillage practices had little effect on this response, according to a U.S. Department of Agriculture (USDA) study.

The first long-term study comparing tillage practices under high CO2 levels showed that elevated CO2

caused soybean and sorghum plants to increase photosynthesis while reducing transpiration-the amount of water the plants release. This resulted in increased water use efficiency, whether the crops were grown with no-till or conventional tillage, according to researchers with USDA's Agricultural Research Service (ARS). ARS is USDA's principal intramural scientific research agency. This study supports the USDA priority of responding to climate change.

Plant physiologist Steve Prior, plant pathologist Brett Runion, and their colleagues at the ARS National Soil Dynamics Laboratory in Auburn, Ala., found that water use efficiency response to high CO2 was much greater for soybeans than for sorghum over the 6-year study.

The outdoor study was done using open-top growth chambers for exposing the crops to the higher levels of CO2. The crops were monitored for photosynthesis and transpiration during their reproductive growth stages, when water demand is highest.

The scientists compared soybean/sorghum rotations with both conventional tillage and no-till. With no-till there is no plowing, only minimal disturbance of the soil while planting seeds. The scientists also compared current ambient CO2 levels—about 370 parts per million (ppm)—with levels of 720 ppm expected within this century.

With the higher level of CO2, regardless of tillage method, soybean photosynthesis increased by about 50 percent, while sorghum photosynthesis rose by only 15 percent. This was expected because crops like soybean, which have a C3 photosynthetic pathway, are known to respond better to high CO2 levels than crops like sorghum and corn that have a C4 photosynthetic pathway. Most plants worldwide are C3 plants.

Sorghum's increased water use efficiency was mainly due to less water transpired or lost through the leaf pores (stomata).

Although no-till didn't make a difference as far as crops responding to high CO2, it can greatly reduce soil erosion, conserve soil water, and increase carbon storage, among its many benefits.

The results of this research were published earlier this year in the *Journal of Environmental Quality.*

Sequencing of Cacao Genome Will Help U.S. Chocolate Industry, Subsistence Farmers in Tropical Regions

WASHINGTON, D.C.—U.S. Department of Agriculture (USDA) scientists and their partners have announced the preliminary release of the sequenced genome of the cacao tree, an achievement that will help sustain the supply of high-quality cocoa to the $17 billion U.S. chocolate industry and protect the livelihoods of small farmers around the world by speeding up development, through traditional breeding techniques, of trees better equipped to resist the droughts, diseases and pests that threaten this vital agricultural crop.

The effort is the result of a partnership between USDA's Agricultural Research Service (ARS); Mars, Inc., of McLean, Va., one of the world's largest manufacturers of chocolate-related products; scientists at IBM's Thomas J. Watson Research Center in Yorktown , N.Y.; and researchers from the Clemson University Genomics Institute, the HudsonAlpha Institute for Biotechnology, Washington State University, Indiana University, the National Center for Genome Resources, and PIPRA (Public Intellectual Property Resource for Agriculture) at the University of California-Davis.

Team leaders from USDA included molecular biologist David Kuhn and geneticist Raymond Schnell, both at the ARS Subtropical Horticulture

Research Station in Miami, Fla., and ARS computational biologist Brian Scheffler at the Jamie Whitten Delta States Research Center in Stoneville, Miss. ARS is the principal intramural scientific research agency of USDA. This research supports the USDA priority of promoting international food security, and USDA's commitment to agricultural sustainability.

"Because of the talent and dedication brought together by this unique partnership, researchers and plant breeders will be able to accelerate the genetic improvement of the cacao crop now cultivated in tropical regions around the world," said Edward B. Knipling, ARS administrator. "This will benefit not only the chocolate industry, but also millions of small farmers who will be able to continue to make their living from cacao."

Cocoa comes from the cacao tree, Theobroma cacao. The tree seeds are processed into cocoa beans that are the source of cocoa, cocoa butter and chocolate. But fungal diseases can destroy seed-bearing pods and wipe out up to 80 percent of the crop, and cause an estimated $700 million in losses each year.

Worldwide demand for cacao now exceeds production, and hundreds of thousands of small farmers and landholders throughout the tropics depend on cacao for their livelihoods. An estimated 70 percent of the world's cocoa is produced in West Africa.

Scientists worldwide have been searching for years for ways to produce cacao trees that can resist evolving pests and diseases, tolerate droughts and produce higher yields. ARS researchers have been testing new cacao tree varieties developed with genetic markers. But having the genome sequenced is expected to speed up the process of identifying genetic markers for specific genes that confer beneficial traits, enabling breeders to produce superior new lines through traditional breeding techniques.

Sequencing cacao's genome also will help researchers develop an overall picture of the plant's genetic makeup, uncover the relationships between genes and traits, and broaden scientific understanding of how the interplay of genetics and the environment determines a plant's health and viability.

The genome sequence will be released into the public domain, with access to these data online via the Cacao Genome Database (www.cacaogenomedb.org) prior to formal peer-reviewed publication. This release will enable the sequence data to be applied immediately to cacao genetic improvement.

The research team will continue to improve the quality and analyze the properties of the cacao genome sequence in preparation for publication in a peer-reviewed journal.

Small Business Success Spotlighted by USDA at Conference

ChoiceBatter's® transformation from a federal laboratory bench technology to a grocery shelf product is among topics that will be discussed here today by U.S. Department of Agriculture (USDA) officials and other participants attending the 17th annual conference of the National Association of Seed and Venture Funds (NASVF).

ChoiceBatter®, the brand name for a line of low oil-uptake batters marketed by CrispTek, LLC, of Columbia, Md., is based on a rice-flour formulation created by Fred Shih and Kim Daigle, chemists with the Agricultural Research Service (ARS), USDA's principal intramural scientific research agency.

In tests from 1998-2000, fried chicken, fish and veggies coated in the rice flour batter absorbed up to 50 percent less cooking oil than traditional wheat batters. The rice batter also produced a crisp, golden-

brown coating. But existing food companies didn't show any interest in the product, and the recipe languished for several years.

However, following the creation in 2007 of a unique program called the Agricultural Technology Innovation Partnership (ATIP) under the auspices of ARS' Office of Technology Transfer (ARS-OTT), CrispTek licensed the patent in April 2008 and was able to commercially develop and begin selling the rice batter.

"We established this program out of recognition that a federal research agency like ours is limited by mission and resources as to what services it can provide to industry partners who can commercialize and market the outcomes of federal research," said Rick Brenner, Assistant Administrator for ARS-OTT in Beltsville, Md.

"ChoiceBatter® is an ideal case study," he added, "because it demonstrates the complexity of turning a federal innovation into a commercial product, as well as illustrates the ATIP program's effectiveness in leveraging necessary assets to fast-track a promising technology towards commercialization."

Under the ATIP program, ARS has signed Partnership Intermediary Agreements with nine regional economic-development entities strategically located around the country. The program is represented nationally by NASVF as the tenth member.

In the case of ChoiceBatter®, ARS partnered with ATIP's inaugural member, the Maryland Technology Development Corporation, to provide CrispTek with technical, financial and other support. "CrispTek represents an outstanding early success of this novel program," said Brenner.

At today's conference, Brenner and other presenters will discuss highlights of a forward-looking economic impact assessment, including 2014 sales projections, which ARS and NASVF commissioned based on first-year sales data. The report shows the economic impact resulting from the manufacture and sale of ChoiceBatter® in five states: Maryland, Illinois, Iowa, Texas and Louisiana. An additional focus of CrispTek's cooperative research agreement with ARS is expanding that economic impact.

ARS is a leader in the federal government in transferring and marketing new technologies developed from its research, and has formed numerous partnerships using cooperative agreements. More information about opportunities for licensing ARS technologies is available on the ARS-OTT website.

NASVF is an international organization whose mission is to advance innovation capital by promoting investments in seed and early-stage companies through supporting entrepreneurship and job creation via innovation-capital programs.

Vaccines Could Help What's Ailing Fish

U.S. Department of Agriculture (USDA) scientists are developing vaccines to help protect healthy farm-raised catfish against key diseases.

Working as a team, microbiologist Phillip H. Klesius and molecular biologists Julia Pridgeon and Craig Shoemaker with USDA's Agricultural Research Service (ARS) at the agency's Aquatic Animal Health Research Unit in Auburn, Ala., and Joyce J. Evans, aquatic pathologist at the Auburn unit's lab in Chestertown, Md., are developing vaccines against *Streptococcus iniae, S. agalactiae* and other pathogens.

ARS is USDA's principal intramural scientific research agency. This research supports the USDA priority of promoting international food security.

The scientists modify the genetic makeup of pathogens to make them nonvirulent, and then develop vaccines that expose fish to low doses of the modified forms of the pathogens.

Klesius and Pridgeon have developed a modified live *S. iniae* vaccine that appears to be superior to inactivated or killed vaccines. The live modified vaccine has enough similarity with the pathogen to create a lifelong immunity in fish, according to Klesius.

Scientists are looking at new methods to vaccinate fish. But for now, the vaccination process consists of immersing the fish in water that contains the modified pathogen.

Previous research breakthroughs have benefited the catfish industry. For example, a ARS-developed vaccine against the pathogen *Edwardsiella ictaluri,* which causes enteric septicemia, has been widely adopted by fish growers.

In an earlier trial, the vaccine against enteric septicemia of catfish was tested by Mississippi State University researchers. Results showed a 12 percent increase in the survival rate of fish that were given the vaccine, and a substantial increase in returns for producers who used the vaccine in their ponds.

USDA Soil Lab Celebrates 75 Years of Innovative Research

The U.S. Department of Agriculture (USDA)'s National Soil Dynamics Laboratory (NSDL) here today marked its 75th anniversary with a celebration of the unit's research accomplishments that have ranged from creation of a new soil science discipline to contributions to undersea cable communications technology. The laboratory has been operated since 1953 by the Agricultural Research Service (ARS), USDA's chief intramural scientific research agency.

Originally known as the Farm Tillage Machinery Laboratory, the facility was built in 1935 on the campus of Auburn University. It is renowned for its 13 historic soil bins, each about the length of a football field, said H. Allen Torbert, NSDL research leader. The laboratory was named an historic landmark in 1990 by the American Society of Mechanical Engineers and the American Society of Agricultural Engineers.

The bins, which resemble huge outdoor bowling lanes, are used for testing the impact of farm equipment on soil. The bins hold the major soil types found in the southeastern United States, varying from sand to clay.

"The outdoor bins were needed to conduct research on the effects of full-scale machines," Torbert explained. "The NSDL was the world's first full-size outdoor laboratory for tillage tools and traction equipment, and its research spawned the scientific discipline of soil dynamics and influenced the design of almost all modern agricultural equipment."

During World War II, the laboratory was shared with the U.S. Army, which conducted research on traction of military equipment. During the 1960s, the laboratory helped design a "sea plow" used to bury trans-Atlantic communication cables. More recent research activities have included collaboration with the Army on ways to convert garbage into pulp that can be used to improve soils and help establish native grasses in heavily used areas such as training grounds.

Current studies include work on how different farm management practices, such as conservation tillage and crop rotations, affect farm productivity and impact the soil's ability to store carbon from the atmosphere, thereby slowing increases in greenhouse gases and reducing soil erosion and compaction.

In addition to Torbert, participants at today's celebration included Edgar G. King, ARS Mid-South Area Director; and former NSDL directors Arthur W. Copper, who led the lab from 1953 to 1966, Robert L. Schafer and Charles Elkins, who together related the

history of the laboratory. The program also included an overview of current and future research at NSDL.

USDA Researchers Seek New Ways to Boost Catfish Production

A U.S. Department of Agriculture (USDA) scientist is exploring new ways to enhance farm-raised catfish production with a device he calls the "see-saw."

Les Torrans, a fish biologist with USDA's Agricultural Research Service (ARS), has built a vertical-lift egg incubator designed to provide a better mix of dissolved oxygen to boost hatching rates of catfish eggs. Torrans works at the ARS Catfish Genetics Research Unit of the Thad Cochran National Warmwater Aquaculture Center located at the Mississippi State University (MSU) Delta Branch Experiment Station in Stoneville, Miss.

ARS is USDA's principal intramural scientific research agency. This research supports the USDA priority of promoting international food security.

Before constructing the see-saw, Torrans discovered evidence that verified precisely how oxygen levels affect catfish egg development and hatching. He then teamed with James Steeby, MSU associate professor emeritus, to develop specific dissolved-oxygen management recommendations for catfish hatcheries.

According to Steeby and Torrans, data collected on catfish egg and fry metabolism showed that variable hatch was frequently caused by insufficient dissolved oxygen in the water. Poor water circulation around and through egg masses contributed to the problem.

Stress caused by low levels of dissolved oxygen, resulting from poor water circulation through egg masses at higher egg loading rates, can reduce the hatching rate, according to Torrans. The see-saw is designed to improve hatch with higher egg loading rates.

With the see-saw system, egg masses are dipped in water and then lifted out before being dipped again. The eggs remain wet, enabling them to exchange gas across the egg membrane. Because there is usually more oxygen in air than in water, the see-saw can take advantage of the water dipping to maintain developing eggs' moisture while using the air for oxygen delivery.

Using the see-saw may allow hatchery operators to increase egg hatch rate, while using half as much water and space as traditional systems, according to Torrans.

Overseas Lab Seeks U.S. Weed Control "Recruits"

The search is on for insects, mites, microbes or nematodes that could be used in a biologically based approach to controlling silverleaf nightshade, an invasive weed from the Americas that has spread to southern Europe, Africa, India, Australia and elsewhere.

According to U.S. Department of Agriculture (USDA) entomologist Walker Jones, the perennial weed, *Solanum elaeagnifolium,* is being targeted for its ability to outcompete native plants, reduce crop yields and diminish pasture productivity. Its orange, toxin-producing berries can also poison livestock.

Severe infestations of silverleaf nightshade can render chemical or mechanical controls, like mowing, too costly, impractical or environmentally harmful to use, added Jones. He initiated the search for the weed's natural enemies as director of the European Biological Control Laboratory (EBCL), operated in Montpellier, France, by the Agricultural Research Service (ARS). ARS is USDA's principal intramural scientific research agency, and this research supports the USDA priority of promoting international food security.

Also of Interest

Before returning to the United States this past April to lead the ARS Biological Control of Pests Research Unit in Stoneville, Miss., Jones, together with ARS National Program Leader Daniel Strickman, established a cooperative project with the Benaki Phytopathological Institute in Athens, Greece, to explore starting continental Europe's first-ever classical weed-biocontrol program. Candidate biocontrol agents are typically insects that severely damage or kill targeted weeds, sparing useful plants and striking a balance between the weed and its environment, explained Jones.

Normally, the EBCL serves as a "way station" where promising biocontrol agents collected from Europe, Asia or Africa are screened for potential release into the United States to manage invasive species there. But in this instance, the lab will serve as a receiving point for candidate organisms from North America that could open the door to biologically controlling infestations of the weed in Greece.

The project's early stages include genetically analyzing silverleaf nightshade populations collected from around the world and physically mapping Greece's infestations of the weed and densities using satellite photographs.

Rain Gardens Sprouting Up Everywhere

Rain gardens are increasingly popular with homeowners and municipalities and are mandatory for many communities nationally. U.S. Department of Agriculture (USDA) scientists are finding ways to improve rain gardens so they not only reduce runoff, but also keep toxic metals out of storm drains.

Rain gardens are plantings in depressions that catch stormwater runoff from sidewalks, parking lots, roads and roofs. Rain gardens come in various shapes and sizes, from large basins carved by front-end loaders to small artificial streambed-like formations complete with pebbles. Rain gardens not only slow water down to give it time to soak into the ground and be used by plants, but also filter out sediment and chemical pollutants.

Plant physiologist Rich Zobel at the Agricultural Research Service (ARS) Appalachian Farming Systems Research Center (AFSRC) at Beaver, W.Va., and research associate Amir Hass, who works for West Virginia State University in Institute, W.Va., and is stationed at Beaver, are working on improving rain gardens. They are collaborating with ARS hydrologist Doug Boyer and ARS soil chemist Javier Gonzalez at Beaver, and colleagues at the ARS Southern Regional Research Center (SRRC) in New Orleans, La., and the ARS Eastern Regional Research Center (ERRC) in Wyndmoor, Pa.

ARS is USDA's principal intramural scientific research agency, and this research supports USDA's commitment to agricultural sustainability.

The scientists at the SRRC found that poultry litter biochar-activated carbons created from the charred remains of poultry litter-is a powerful pollutant magnet. It can attract heavy metals such as copper, cadmium and zinc, which are ordinarily tough to snag from wastewater.

ARS chemists Isabel Lima and Wayne Marshall (now retired) at the SRRC developed the ARS-patented method for turning agricultural bio-waste into biochar. They created the biochar by subjecting poultry litter—bedding materials such as sawdust, wood shavings and peanut shells, as well as droppings and feathers—to pyrolysis, a high-temperature process that takes place in the absence of oxygen.

Hass and colleagues are testing the poultry litter biochar as well as other farm and industrial byproducts at two demonstration rain gardens in the Beaver area, as well as at plots at a county landfill and a mineland reclamation site.

Also of Interest

Careful Sleuthing Reveals a Key Source of Sedimentation

Much of the sediment load in Mississippi's streams and rivers doesn't come from field runoff, according to work by scientists at the U.S. Department of Agriculture (USDA). Instead, the scientists with USDA's Agricultural Research Service (ARS) have confirmed that stream bank collapse and failure can be chief contributors to high sediment levels in the silty streams and rivers that flow into the Mississippi. ARS is USDA's chief intramural scientific research agency.

The U.S. Environmental Protection Agency lists sediment as the most common pollutant of rivers, streams, lakes and reservoirs in the United States. Trapped sediment can reduce the useful lifespan of dams and reservoirs, exacerbate flooding, harm aquatic plants and animals, and transport other pollutants downstream. Over the years, billions of dollars have been spent on stream bank protection and restoration efforts to stem erosion and reduce sedimentation loads.

The source of this sediment load is often attributed to erosion and runoff from farm fields. But ARS hydrologist Glenn Wilson, who works at the agency's National Sedimentation Laboratory in Oxford, Miss., spent several years looking more closely at the causes of stream bank erosion. His studies focused on how seepage—the lateral movement of water through the ground—could prompt conditions that led to stream bank failure.

Wilson and others confirmed for the first time that a stable stream bank can quickly become unstable when seepage erosion is added to the mix of factors that promote bank failure. They found that seepage from stream banks was eroding layers of soil that subsequently would wash down the face of the stream bank and into the stream itself. This added to the sediment load in the stream and also left the bank itself weakened and vulnerable to collapse.

The researchers concluded that stream bank failure may stem as much—or more—from the effect of seepage erosion undercutting the stream banks as from the added weight of the waterlogged stream banks.

Results from this work were published in the *Journal of Hydrologic Engineering* and *Earth Surface Processes and Landforms*.

Factors in Berry-Splitting in Blueberries Examined

U.S. Department of Agriculture (USDA) researchers and a university colleague have found several factors involved in blueberry splitting, a significant problem that can cause losses of $300 to $500 per acre.

Splitting and cracking occur in southern highbush and rabbiteye blueberries if they receive preharvest rainfall when fully ripe or approaching ripeness, according to scientists with USDA's Agricultural Research Service (ARS). ARS is USDA's principal intramural scientific research agency.

ARS horticulturist Donna Marshall, retired horticulturist James Spiers and geneticist Stephen Stringer at the ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, Miss., and University of Southern Mississippi associate professor Kenneth Curry collaborated on the research 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 blueberry breeders throughout the country are using this method to more vigorously screen cultivars and selections for splitting susceptibility. The results from field and laboratory tests showed that the rabbiteye cultivar "Premier" has the lowest incidence of splitting, while widely grown cultivar "Tifblue" exhibited a high incidence of splitting.

Also of Interest

Marshall and her 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. According to Marshall, the studies show that splitting is a cultivar-specific problem.

Controlling Starch in Sugar Factories

Factory trials conducted by U.S. Department of Agriculture (USDA) scientists have led to recommendations for controlling or preventing starch buildup in processed raw sugars and products made with those sugars. The study was led by chemist Gillian Eggleston with the Agricultural Research Service (ARS) Commodity Utilization Research Unit in New Orleans, La. ARS is USDA's chief intramural scientific research agency.

Eggleston has been studying sugarcane that comes into factories containing too much field leafy residue called trash. Environmental concerns have led to a shift away from burning cane in open fields to remove such trash. That means more trash or green cane is entering factories. Another challenge: Processing green, unburnt cane results in excess starch in raw and refined sugars, molasses and food products.

An enzyme called amylase is added during U.S. sugar-factory processing to break down long chains of unwanted starch. Eggleston conducted trials in three Louisiana-based factories using an amylase that was intermediate-temperature (IT) stable and in a concentrated form.

Eggleston used diluted solutions of concentrated amylase to improve contact between the amylase and starch. The solutions break starch down into smaller, more manageable molecules when added to factory tanks.

One of the solutions she tested contained concentrated IT-stable amylase diluted three-fold in water at the factory. When this solution was added at a dose of 2 parts per million (ppm) per ton of cane juice, starch breakdown was about 32 percent. When the dose was raised to 5 ppm per ton of cane juice, starch breakdown increased to 42 percent.

In addition, adding the amylase to the next-to-the-last evaporator—instead of the last evaporator as is traditional—improved starch breakdown even more. Another plus: Using diluted solutions of concentrated amylase is more cost-effective than using undiluted non-concentrated amylase.

Results from this work were published in a two-part paper in the *International Sugar Journal.*

USDA's Agricultural Research Service Announces Scientist of the Year and Other Awards

Molecular geneticist Sarah Hake has been named "Distinguished Senior Research Scientist of 2010" by the Agricultural Research Service (ARS) for her scientific leadership, research and seminal discoveries in plant biology that have had a major impact on plant developmental genetics. ARS is the principal

intramural scientific research agency of the U.S. Department of Agriculture (USDA).

Hake is director of the ARS Plant Gene Expression Center in Albany, Calif. She and other ARS researchers and support staff are being honored today at the agency's awards ceremony.

"Dr. Hake's research on plant genetic mechanisms is focused on one of the most important areas of agricultural research today, and her work has placed her among the top scientists in her field," said Edward B. Knipling, ARS administrator. "Her talent, skills and achievements have broadened our understanding of basic plant biology and helped address the challenges associated with producing enough food in a world where the climate is changing and populations are on the rise."

Hake's findings have shed light on how plants develop and have led to advances in areas ranging from agricultural production to evolution. She was the first scientist to clone a developmental gene by using a transposable element or "jumping gene" as a starting point. The gene identified was a type previously thought to exist only in animals, and functions as a master regulator of multiple pathways.

Hake's isolation of other genes has led to a body of knowledge on leaf and flower development in maize currently at the forefront of plant biology studies. She is a member of the National Academy of Sciences, a Fellow of the American Association for the Advancement of Science, and the winner in 2008 of the Hales Award, the most prestigious award given by the 5,000-member American Society of Plant Biologists.

ARS also will recognize the following Area Senior Research Scientists today:

Joan K. Lunney, ARS Animal Parasitic Diseases Laboratory, Beltsville, Md., for significant research contributions and international leadership in determining protective immune mechanisms and genetic resistance for infectious pathogens important to the U.S. swine industry.

N. Andy Cole, ARS Renewable Energy and Manure Management Research Unit, Bushland, Texas, for outstanding research in beef cattle nutrition and in management of environmental impacts of beef cattle feeding operations.

Robert A. Graybosch, ARS Grain, Forage and Bioenergy Research Unit, Lincoln, Neb., for sustained research innovation and productivity leading to wheat cultivars with improved yield, quality, and disease resistance.

Karamat R. Sistani, ARS Animal Waste Management Research Unit, Bowling Green, Ky., for outstanding research and team leadership in using animal wastes to increase crop yields, while protecting water and air quality and controlling pathogens.

Roger P. Wise, ARS Corn Insects and Crop Genetics Research Unit, Ames, Iowa, for distinguished research and leadership in genomics of disease interactions in cereal crops.

James Giovannoni, ARS Plant, Soil and Nutrition Research Unit, Ithaca, N.Y. for international leadership on tomato genomics research, including pioneering discoveries in fruit ripening, as well as leadership of tomato genome sequencing efforts.

Thomas E. Carter, Jr., ARS Soybean and Nitrogen Fixation Research Unit, Raleigh, N.C., for pioneering research on genetic diversity in soybean breeding and the development of the first high-yielding, drought-tolerant soybean germplasm.

ARS also is recognizing outstanding "early career scientists" who have been with the agency for seven years or less. The top prize, the Herbert L. Rothbart

Also of Interest

Outstanding Early Career Research Scientist Award, will be presented to Jonathan G. Lundgren of ARS' North Central Agricultural Research Laboratory, Brookings, S.D. He was recognized for innovative research on multi-trophic interactions within agricultural systems, emphasizing how generalist predators are affected by farm management, and how biodiversity improves pest management.

Other "Area Early Career Research Scientist Award" winners for 2010 are:

Amy L. Vincent, ARS Virus and Prion Diseases Research Unit, Ames, Iowa, for swine influenza virus pathogenesis, transmission and vaccine research supporting the U.S. swine industry.

Brandon T. Bestelmeyer, ARS Range Management Research Unit, Las Cruces, N.M., for research resulting in ecologically based technologies used in management of millions of acres of rangelands in the United States and around the world.

Jeffrey A. Fabrick, ARS Pest Management and Biological Control Research Unit, Maricopa, Ariz., for innovative application of insect biochemistry and molecular biology in understanding and sustaining transgenic crop technology and integrated pest management.

Russell C. Nuti, ARS National Peanut Research Laboratory, Dawson, Ga., for conceiving and conducting research and transferring it to applicable stakeholders in the peanut industry.

Helen L. Ngo, ARS Sustainable Biofuels and Co-Products Research Unit, Wyndmoor, Pa., for research in the development of novel catalysts and catalytic processes for the conversion of fats and oils into biobased products and biofuels.

Ryan P. Viator, ARS Sugarcane Research Unit, Houma, La., for identifying, conducting, and transferring research that meets current and future needs of the sugarcane industry.

George E. Liu, ARS Bovine Functional Genomics Laboratory, Beltsville, Md., for research on cattle genome copy number variations underlying economically important health and production traits.

Knipling also announced the agency's selections for the 2010 ARS Technology Transfer Awards for outstanding work by individuals or groups in transferring technology to the marketplace. Two nominations have been selected for top honors and six others have been cited for superior efforts.

Top honors for outstanding efforts will be presented to Chris M. Maragos, ARS Bacterial Foodborne Pathogens and Mycology Research Unit, Peoria, Ill., for the development of antibodies essential to the manufacture of improved toxin detection assays, and also to the ARS Pacific West Area Potato Breeding Program for development and transfer of new potato varieties in the Pacific Northwest. Members of that team include Charles R. Brown, Roy Navarre and James Crosslin, all of the ARS Vegetable and Forage Crops Research Unit, Prosser, Wash.; and Richard Novy and Jonathan Whitworth, both from the ARS Small Grains and Potato Germplasm Research Unit, Aberdeen, Idaho.

Also being honored for superior technology transfer achievements are:

Xiaoliang Cui, ARS Cotton Structure and Quality Research Unit, New Orleans, La. for outstanding efforts in supporting the transfer of the USDA-AMS process for cotton classification, which helped facilitate the sale of U.S. cotton to China.

C. Corley Holbrook, ARS Crop Genetics and Breeding Research Unit, Tifton, Ga., for development and transfer of Tifguard, the first high-yielding peanut

Also of Interest

cultivar with resistance to both the peanut root-knot nematode and tomato spotted wilt virus.

The H1N1 Pandemic Influenza Veterinary Team f or rapid response to H1N1 pandemic influenza by timely development and transfer of diagnostic tests for veterinary specimens. The team includes David Suarez and Erica Spackman, ARS Southeast Poultry Research Laboratory, Athens, Ga.; and Beverly Schmitt, Sabrina Swenson, Mary Lea Killian, Janice Pedersen, Leo Koster and Melinda Jenkins-Moore, all of the APHIS National Veterinary Services Laboratories, Ames, Iowa.

The Aerial Application Technology Team at the ARS Areawide Pest Management Research Unit, College Station, Texas, for the transfer of spray application technology to the Florida citrus industry for enhanced control of citrus greening disease. The team includes W. Clint Hoffmann, Bradley K. Fritz, Daniel E. Martin, and Christopher T. Parker.

The ARS Predictive Microbiology for Food Safety Team at the Eastern Regional Research Center (ERRC), Wyndmoor, Pa., for developing and expanding the USDA Pathogen Modeling Program, Predictive Microbiology Information Portal (PMIP) to enhance the safety of the nation's food supplies. The team includes Vijay Juneja, Cheng-An Hwang, Lihan Huang, Tom Oscar and Shiowshuh Sheen.

The Winter Barley team, also based at the ERRC, for developing and transferring technology that promotes energy independence and the rural economy by providing assistance to the Mid Atlantic winter barley ethanol industry. The team includes Kevin Hicks, John Nghiem, Andy McAloon, Winnie Yee, Frank Taylor, David Johnston, Edna Ramirez (retired), Rolando Flores, Robert Moreau, Mike Kurantz, Jhanel Wilson, Gerard Senske, all of ERRC; and industry partners Jay Shetty, Gerhard Janda-Konieczny and Mian Li, all of Genencor International; Bob Randle, formerly of Genencor International; Pat Simms, Eric Lee, Hank Bisner, Craig Shealy, John Warren and Bill Scruggs, all of Osage Bio Energy; Wynse Brooks, Carl Griffey, Wade Thomason and Mark Vaughn, all from Virginia Tech; Bruce Beahm, Virginia Crop Improvement Association, and Dan Brann, Brann Farms.

Richard Beeman of the ARS Stored Product Insect Research Unit, Manhattan, Kan., is the recipient of the agency's T.W. Edminster Award for proposed research to engineer a new red flour beetle cell line for analysis of gene expression and gene silencing. The work could lead to practical methods for controlling insect pests. The T.W. Edminster Award is given annually to the researcher who submits the highest rated research proposal in the ARS Postdoctoral Research Associate Program.

Administrator's Outreach, Diversity, and Equal Opportunity Awards are being presented to Kim E. Hummer, ARS National Clonal Germplasm Repository, Corvallis, Ore., for excellence in student and community outreach, and to Savithiry Natarajan, ARS Soybean Genomics and Improvement Laboratory, Beltsville, Md., for extraordinary efforts in motivating K-12 minority students to pursue careers in science. The awards recognize employees for promoting equal employment opportunity and civil rights and fostering an awareness of and commitment to workforce diversity.

The 2010 Excellence in Information Award is being presented to Andrew Meerdo for developing unique informational and instructional videos and a web site for the ARS Forage and Range Research Laboratory in Logan, Utah.

The Office Professional of the Year Award is being given to Beth A. Holt for contributions that enhanced scientific productivity at the ARS Conservation and Production Research Laboratory in Bushland, Texas and in the Southern Plains Area.

Also of Interest

The following ARS employees also are being honored for exemplary service in Administration and Financial Management (AFM):

Gold Award for Excellence: James W. Tyler, retired, formerly administrative officer of the Southern Regional Research Center, New Orleans, La.;

Silver Award for Excellence: Sandy Morgan, AFM, Beltsville, Md.;

Bronze Awards for Excellence: Debra Vandergrift, AFM, Washington, D.C. and the Research Position Evaluation Staff (RPES), Beltsville, Md. RPES staff members include Merle Cole, Wendy Hatcher, Pat Humphrey and Dana Lamberti.

Lowering the Color of Crystals in Sugar Factories

Like diamonds, sugar crystals ideally are very pure and low in color. Now studies led by U.S. Department of Agriculture (USDA) chemist Gillian Eggleston have provided a better understanding of the source of undesirable color in factory sugar.

Eggleston works in the Agricultural Research Service (ARS) Commodity Utilization Research Unit in New Orleans, La. She conducted the studies with Barbara Muir of the Sugar Milling Research Institute in Durban, South Africa. ARS is USDA's chief intramural scientific research agency.

Environmental concerns have led to a shift away from burning cane in open fields to remove "trash," which is impurities such as leaves, tops and muddy soil that piggyback on sugarcane from the field into the factory. More trash comes into the factory on green cane than on burnt cane.

Traditionally, several processes have been used in factories or refineries to lower or remove color, but they are all expensive. The authors estimate that for every 1 percent increase in trash levels, there is an increase of about 50 international color units for raw sugar and 25 such units for refinery sugar. They also found that for every 1 percent increase in trash, there is about a one-fifth-percent drop in recoverable crystals. That translates into upwards of a $100 million loss per year to the U.S. sugarcane industry.

Based on samples produced across a pilot plant that simulated all factory processes, green cane detrimentally affected purity, sugars, ash and color as well as physical properties such as clarification performance, according to Eggleston. The data show that undesirable color in factory sugar is actually coming from the green leaves and the growing-point region which occurs at the top part of the stalk.

Eggleston's collaborative work has led to a recommendation to sugarcane growers and processors that even a small reduction—such as less than 10 percent—in total trash levels processed at the factory could be more efficient and cost-effective than other factory color-removal processes. This award-winning study was published in the *Proceedings of the South African Sugar Technologists' Association.*

ARS and Cooperators Study Cotton Gin Dust Emissions

The last of seven cotton gins is being tested this year as the fieldwork for a major 4-year cotton gin dust sampling project draws to a close. U.S. Department of Agriculture (USDA) scientists organized the project to intensively sample emissions from seven cotton gins across the Cotton Belt.

Mike Buser, formerly with the Agricultural Research Service (ARS) Cotton Production and Processing Research Unit in Lubbock, Texas, and now with Oklahoma State University at Stillwater, began the project with fellow ARS agricultural engineers Derek

Also of Interest

Whitelock at the agency's Southwestern Cotton Ginning Research Laboratory in Mesilla Park, N.M., and Clif Boykin at the agency's Cotton Ginning Research Unit in Stoneville, Miss. ARS is USDA's principal intramural scientific research agency.

While at Lubbock, Buser had found that U.S. Environmental Protection Agency (EPA) computer models and dust samplers may overestimate both the distance gin dust travels and the concentrations of the smallest particles. Buser continues this research as an integral part of the "Characterization of Cotton Gin Particulate Matter Emission Project."

In 2006, EPA lowered the limit on average Particulate Matter (PM)2.5 emissions over a 24-hour period from 65 to 35 micrograms per cubic meter. This comes from a growing concern that the smallest dust particles pose the biggest health threat because they are small enough to penetrate deeply into peoples' lungs. PM2.5 refers to dust particles less than 2.5 microns in diameter, less than one-thirtieth the thickness of a human hair.

As states implement required plans to achieve federal standards—or even stricter ones—they face the problem of a scarcity, or, in some cases, a complete lack of data on how much PM2.5 industries emit.

The cotton industry and EPA and state regulators helped plan the project.

The exhaust from each gin's dust control devices is sampled, and outside dust is measured by 126 ambient air samplers surrounding each gin.

To date, sampled gins include one in New Mexico, two in Texas, two in California, and one in Missouri; the last is in North Carolina. It will take another year, through 2012, to analyze all the data.

Cotton's Potential for Padding Nonwovens

U.S. Department of Agriculture (USDA) scientists have conducted studies to investigate the use of virgin cotton in nonwoven materials and products. The work was led by cotton technologist Paul Sawhney and his colleagues at the Agricultural Research Service (ARS) Cotton Chemistry and Utilization Research Unit in the agency's Southern Regional Research Center (SRRC) in New Orleans, La.

Sawhney is the lead scientist of the cotton-based nonwovens research program at the center. ARS is USDA's chief intramural scientific research agency.

Raw, virgin lint, which is ginned cotton that has not been washed and bleached, is referred to by the industry as "greige" cotton (pronounced "grey" cotton). Virgin cotton is considered less expensive and less complex to process compared to bleached cotton or other synthetics.

About 98 percent of cotton produced worldwide is used in traditional woven textiles. Nonwovens are made of tangled fibers and are produced in a continuous-sheet form at a relatively faster rate compared to that of woven fabrics. At first, nonwoven fabrics were made using only synthetic polymer-type fibers. As nonwovens fabric materials became more popular, some manufacturers began adding cotton.

The SRRC has added nonwoven machinery and equipment to its Cotton Nonwovens Research Laboratory and Pilot Facility. Studies showed that ginned virgin cotton could be processed directly on some traditional cotton fiber equipment. The cotton's natural waxes provided a measure of lubrication that was beneficial, when compared to bleached cotton fibers similarly processed.

The researchers also successfully processed the virgin cotton on the center's newer nonwoven fabrics

production equipment. For example, the team found that greige cotton, which is naturally water repellent, can be made absorbent mainly by controlling the water pressure that entangles fibers during processing.

The researchers' findings have been published in *Textile Research Journal.*

Gypsies, Graveyards and Mysterious Plants

A U.S. Department of Agriculture (USDA) scientist has confirmed the identity of a strange grass-like sedge discovered in a Mississippi graveyard, and believes the appearance of the potentially invasive plant is linked to the final resting places of several members of a royal Gypsy family.

Agricultural Research Service (ARS) botanist Charles Bryson was asked by Mississippi State University graduate student Lucas Majure to help classify a plant Majure had found in Rose Hill Cemetery in Meridian, Miss. Bryson works at the ARS Crop Production Systems Research Unit in Stoneville, Miss. ARS is USDA's chief intramural scientific research agency.

After several months of searching, Bryson identified the plant as blue sedge *(Carex breviculmis)*, a native of Asia and Australia and previously unknown in North America. He also found it growing along railroad tracks, campgrounds used by transients, and in or around four cemeteries in Meridian, including Rose Hill Cemetery.

Visitors from all over the world come to Rose Hill Cemetery to pay their respects at the gravesite of Kelly Mitchell, the Queen of the Gypsies, who was buried there in 1915. Her husband and other family members were also laid to rest in the cemetery.

Given the plant's restricted and distinctive distribution in the region, Bryson thinks that global travelers introduced the sedge to Mississippi, possibly via seeds trapped in clothing or by leaving plants or soil at the gravesites of the Gypsy royalty. Then cemetery caretakers may have spread plant material from the first introduction site to the other cemeteries via contaminated clothing and lawn care equipment.

At two sites where it is now established, the plant exhibits weedy characteristics and reproduces and spreads profusely. To Bryson, these traits suggest that the Old World sedge could someday cause problems in U.S. lawn and turf systems, as well as in fruit and nut crop production.

Bryson and Majure published their findings in the *Journal of the Botanical Research Institute of Texas.*

Special Delivery: Nematode-infected Insect Cadavers

A custom-made machine for packaging mealworms infected with beneficial nematodes could improve the delivery, timing and use of the wormlike organisms as biological control agents.

The machine is the result of a cooperative research and development agreement involving U.S. Department of Agriculture (USDA) scientists and Southeastern Insectaries, Inc., of Perry, Ga.

The *Heterorhabditis* and *Steinernema* nematodes being used can infect and kill a wide array of insect crop pests, including Japanese beetles, vine weevils, root borers and fungus gnats. About 10 years ago, entomologist David Shapiro-Ilan and colleagues with USDA's Agricultural Research Service (ARS) and Virginia Polytechnic Institute and State University showed that the nematodes performed best when applied in the dead bodies of the insect hosts used to mass-produce them. Pest control is then achieved by the nematode progeny that emerge from the insect cadavers. ARS is USDA's principal intramural scientific research agency.

A technical hurdle that's kept the insect-cadaver approach from gaining widespread commercial acceptance is the tendency of some commonly used host insects to rupture or stick together during storage, transport and application.

Southeastern Insectaries owner Louis Tedders came up with a solution, namely, packaging the insects in masking tape. He also devised a prototype device to automate the process, which ARS scientists Juan Morales-Ramos and Guadalupe Rojas in Stoneville, Miss., subsequently refined.

Using off-the-shelf parts, for example, they built a device to mechanically sort mealworms by size, with the biggest ones chosen for placement in shallow dishes where nematodes could infect them. After a few days, a mechanical arm reaches in and places the dead, infected mealworms between strips of masking tape at the rate of one insect every two seconds. Eventually, an entire roll is formed, allowing for easy storage, transport and application to pest-infested soils.

Shapiro-Ilan's laboratory tests of the insect-cadaver taping system showed no adverse effects on the nematodes' survival and pest-control ability. Indeed, 15 days after application, nematodes from the taped cadavers killed up to 78 percent of small hive beetles and 91 percent of root weevils used in the tests.

Nanotech Cotton Opens Up New Possibilities for the Fiber—and its Fans

Cotton is going high-tech in New Orleans, La., where a team of U.S. Department of Agriculture (USDA) scientists is continuing a long tradition of innovative research on the prized natural fiber.

Starting in the 1950s, chemist Ruth Benerito and her colleagues at the Agricultural Research Service (ARS) Southern Regional Research Center in New Orleans conducted groundbreaking studies that gave rise to easy-care, permanent-press clothing and other consumer-friendly improvements that helped cotton better compete with synthetic fibers, like polyester. Today, under the leadership of Brian Condon, the ARS cotton researchers in New Orleans are leveraging the latest developments in nanotechnology to bring cotton fully into the 21st century.

ARS is the chief intramural scientific research agency of USDA.

In one ongoing project, the researchers have teamed with Texas A&M University scientists to evaluate a first-of-its-kind, environmentally friendly flame-retardant for cotton apparel and durable goods. Halogenated flame retardants have been among the most widely used chemical treatments, but there's been a push to find alternatives that are more benign and that won't cause treated fabric to stiffen, according to Condon.

Made of water-soluble polymers, 50- to 100-nanometer clay particles and other "green" ingredients, the experimental fabric treatment reacts to open flame by rapidly forming a swollen charred surface layer. This stops the flame from reaching underlying or adjacent fibers in a process known as "intumescence," notes Condon, co-author of a May 2010 ACS Nano paper.

Early trials of the nanocoating using standard flame-resistance tests have been promising. In one case, 95 percent of treated cotton fabric remained intact after exposure to flame versus complete destruction of untreated fabric used for comparison.

In another project, the ARS scientists are generating ultrasonic fields of mechanical energy to improve enzyme-based processing of raw ("greige") cotton to strip away waxes and other fiber components that can hinder subsequent dying procedures and diminish product quality.

Also of Interest

Soil Erosion Modeling: It's Getting Better All the Time

About 50 years ago, scientists at the U.S. Department of Agriculture (USDA) devised the Universal Soil Loss Equation (USLE), a formula farmers could use to estimate losses from soil erosion. Agricultural Research Service (ARS) scientists will soon release a version that integrates models generated by cutting-edge computer technology, an updated soils database, and new findings about erosion processes.

ARS is USDA's chief intramural scientific research agency, and this work supports the USDA priority of promoting international food security.

The original USLE used five factors to estimate the tons of soil lost per acre per year from the impact of raindrops and the flow of runoff water across fields disturbed by plowing and tilling. The formula is now used as the basis for estimating soil erosion wherever land is disturbed by farming or other human activities.

Every conservation plan written by the USDA Natural Resources Conservation Service has been based on soil-erosion calculations derived from USLE or its successors, the Revised Universal Soil Loss Equation (RUSLE) and version 2 (RUSLE2). Now research leader Seth Dabney, who works at the ARS Watershed Physical Processes Research Unit in Oxford, Miss., is putting the finishing touches on an update of RUSLE2, which uses more intricate combinations of observation- and process-based science to produce soil erosion estimates.

New formulas have been added that can generate simulations of pasture plant lifecycles, which in turn can be used to estimate the effects livestock and their different grazing patterns will have on soil erosion. The revised equations can also produce estimates of how much plant residue can be removed from crop and pasture lands for ethanol production without exposing the soil to excessive erosion.

RUSLE2's revised database contains information for the entire United States on climate and soil properties that affect erosion. The database also includes detailed descriptions of management systems that are organized in 75 crop management zones nationally. RUSLE2 can now also be used to predict runoff amounts and to develop a representative runoff event sequence that can be linked with a process-based channel erosion model.

More information about RUSLE2 can be found at http://www.ars.usda.gov/Research/docs.htm?docid=5971.

Biocontrol Agent Tested to Battle Invasive Kudzu Bug

Don't let its common name fool you: The "kudzu bug" isn't to be trusted.

Sure, it will feed voraciously on the stems of kudzu, the "Vine That Ate the South." But *Megacopta cribraria* also has a taste for legumes, including soybeans. And in Georgia, where this native of Asia was first discovered in October 2009, there's worry the pest will infest peanuts, endangering the state's $2-billion legume crop.

U.S. Department of Agriculture (USDA) scientists and their collaborators haven't been idle, however. At the Agricultural Research Service (ARS) Stoneville Research Quarantine Facility in Stoneville, Miss., entomologist Walker Jones is evaluating a top natural enemy of the bug, the parasitic wasp *Paratelenomus saccharalis.* ARS is USDA's principal intramural scientific research agency.

The wasp is nonstinging and harmless to humans, pets and other animals. However, it lays its eggs in those of *Megacopta's.* Upon hatching, the wasp's maggot-like brood devour the pest's own developing embryos, reducing the size of the next generation.

Also of Interest

Megacopta belongs to a unique insect family that doesn't occur anywhere in the Americas. Thus, importing its co-evolved natural enemies isn't expected to endanger native U.S. bug species, explains Walker, who leads the ARS Biological Control of Pests Research Unit in Stoneville. First, however, the wasp must pass muster on a long list of requirements to confirm its host specificity and environmental safety, starting with the quarantine trials.

Toward that end, Walker is screening eggs of native species of related bugs to learn whether the wasp will attack them, and so far it hasn't. The evaluations require a steady supply of bugs representing four families and 15 species sent to Walker by collaborators across the country.

Besides Georgia, *Megacopta* has also been reported in parts of Alabama, Tennessee, North Carolina, South Carolina and Virginia. A university-led effort is tracking the pest's spread and studying its basic biology, host crop range, economic impact, chemical control and vulnerability to native predators, parasites and pathogens.

New Treatments Could Reduce Odors in Cotton Fabric

Socks, T-shirts and other garments could become less hospitable to odor-causing bacteria, thanks to new antimicrobial treatments being investigated by U.S. Department of Agriculture (USDA) scientists in New Orleans, La.

In studies at the Southern Regional Research Center operated there by USDA's Agricultural Research Service (ARS), a team of scientists is seeking to inhibit microbial growth in cotton using silver particles ranging from 2 to 6 nanometers in size. ARS is USDA's chief intramural scientific research agency.

Silver nanoparticles have been used previously as antimicrobial agents in products, including clothes, plastic food containers and medical textiles. However, the synthetic methods of producing them have relied on the use of toxic agents and organic solvents, according to ARS team leader Brian Condon.

As an environmentally friendly alternative, his team showed that polyethylene glycol and water worked just as well in generating the silver particles. Moreover, the particles were of the desired size, reported Condon, ARS engineer Sunghyun Nam, and former ARS researcher Dharnidhar Parikh, in a recent issue of the *Journal of Nanoparticle Research.*

The researchers also devised a method of prompting silver nanoparticles to form directly on cotton fibers, eliminating the handling and storage of the antimicrobial agents prior to application. This should give cotton an advantage over synthetic fabrics, which have not been amendable to silver nanoparticle treatment, notes Condon, who leads the ARS center's Cotton Chemistry and Utilization Research Unit.

In another approach, ARS chemist Vince Edwards, together with Condon, developed a treatment for impregnating nonwoven cotton fabrics with lysozyme, an enzyme that slices open the cell walls of microorganisms, killing them—including those that cause odor or infection. Similar enzymes also have potential use in biodefense applications, such as deactivating nerve agents, adds Condon.

The researchers are seeking commercial partners to help usher the advances into the marketplace, all with an eye towards assuring the viability of American cotton at a time of increasing production costs, dwindling resources and global competition.

Also of Interest

USDA's Agricultural Research Service Announces Scientist of the Year Awards

WASHINGTON—Edward S. Buckler has been named Distinguished Senior Research Scientist of 2011 by the Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA) for conducting landmark studies of corn that have placed him at the forefront of plant genetics, improved the crop's nutritional value, and led to the development of molecular tools now being used to study the genetic underpinnings of a wide range of plants and diseases. ARS is USDA's principal intramural scientific research agency.

Buckler is a geneticist and senior scientist at the ARS Robert W. Holley Center for Agriculture and Health in Ithaca, N.Y. He and other ARS researchers are being honored today at a ceremony in Beltsville, Md.

"By taking such a comprehensive approach to the study of the natural variation found in cereal crops, Dr. Buckler has enhanced the value of a major U.S. commodity and is addressing nutritional problems that plague many parts of the world," said Edward B. Knipling, ARS administrator.

Buckler led a team that developed a powerful genetic mapping platform for maize, or corn, lines. The platform proved instrumental in studies that identified genes controlling important agronomic traits, such as those involved in local adaptation. In one study, Buckler and his team surveyed the levels of corn genome for carotenoid (pro-vitamin A) to address Vitamin A deficiencies, a problem that can cause childhood blindness and immune deficiencies, particularly in sub-Saharan Africa and Latin America. Buckler and his team worked with international collaborators to identify key genes and alleles that enabled breeders to develop varieties with 15 times more pro-Vitamin A.

ARS also will recognize the following Area Senior Research Scientists today:

Marcus E. Kehrli, Jr., ARS Virus and Prion Research Unit, National Animal Disease Center, Ames, Iowa, for sustained excellence in animal health research.

David C. Goodrich, ARS Southwest Watershed Research Center, Tucson, Ariz., for advances in eco-hydrology, leadership in interdisciplinary research and integration of science into watershed management policies.

Kevin B. Jensen, ARS Forage and Range Research Laboratory, Logan, Utah, for consistent leadership and productivity in development and release of germplasm and forage cultivars that have major impacts.

Bosoon Park, ARS Quality and Safety Assessment Research Unit, Athens, Ga., for research in hyperspectral and real-time multispectral imaging and nanotechnology for food safety.

Jeffrey G. Arnold, ARS Grassland Soil and Water Research Laboratory, Temple, Texas, for developing the SWAT model and other hydrologic and water quality support tools to solve water resource conservation and management problems worldwide.

Craig S.T. Daughtry, ARS Hydrology and Remote Sensing Laboratory, Beltsville, Md., for research in theory and applications of remote sensing for assessing crops and soils.

ARS is also recognizing outstanding "early career scientists" who have been with the agency for seven years or less. The top prize, the Herbert L. Rothbart Outstanding Early Career Research Scientist Award, will be awarded to Christina L. Swaggerty, ARS Food and Feed Safety Research Unit, College Station, Texas, for research to enhance the safety, security and wholesomeness of the U.S. food supply.

Also of Interest

Other "Area Early Career Research Scientist Award" winners for 2011 are:

Adam S. Davis, ARS Global Change and Photosynthesis Research Unit, Urbana, Ill., for contributions in the development of economically and environmentally sustainable management of weeds.

Daniel Cook, ARS Poisonous Plant Research Laboratory, Logan, Utah, for investigations of physiology and chemotaxonomy of toxic plants and teamwork with collaborators and other members of the research unit.

Lance Cadle-Davidson, ARS Grape Genetics Research Unit, Geneva, N.Y., for partnering with the grape industry to identify genetic resistance to powdery mildew and forming research collaborations to advance grape pathology, genetics and genomics.

Julia Wei Pridgeon, ARS Aquatic Animal Health Research Laboratory, Auburn, Ala., for inventing vaccines to protect fish against bacterial diseases.

B. Todd Campbell, ARS Coastal Plains Soil, Water, and Plant Research Center, Florence, S.C., for crop science research advances combining genomics and plant breeding.

Monica Santin-Duran, ARS Environmental Microbial and Food Safety Laboratory, Beltsville, Md., for research to discover pathogens of public health concern in food animals.

Knipling also announced his selections for the 2011 ARS Technology Transfer Awards for outstanding work in transferring technology to the marketplace. Individuals and groups are being recognized in two categories: for achievements with immediate impacts on the marketplace, and for achievements that represent five to 15 years of sustained effort. In each category, top awards were given for outstanding achievement and scientists also were cited for superior efforts.

Honors for outstanding achievement went to the ARS Southern Regional Research Center in New Orleans, La., for developing Choice Batter, a rice-based frying batter sold nationwide. Team members include ARS scientists Kim Daigle and Fred Shih (retired), both with the center's Food Processing and Sensory Quality Research Unit; and outside partners Wayne Swann, Ron Friedman, Roch Kallmyer, John Howell, and Ray Jones, all of CrispTek, Columbia, Md.

Selected for superior technology transfer achievements were:

Gloria DeGrandi-Hoffman, ARS Carl Hayden Bee Research Center, Tucson, Ariz., for developing Hopguard, a product that safely and effectively controls Varroa mites in honey bee colonies.

Gregory Holt, ARS Cotton Production and Processing Research Unit, Lubbock, Tex., for developing technology that uses cotton gin byproducts for biodegradable packaging and insulation board.

The Wheat Improvement Team in Raleigh, N.C., for developing specialty wheat varieties for farmers, millers, and bakers and for organic markets in North Carolina. Team members include Myron Fountain, Lynda Whitcher and Charlie Glover, all in the ARS Plant Science Research Unit, Raleigh; David Marshall, research leader of the unit and who is serving a detail as ARS national program leader for grain crops; and cooperator Bill Brown, North Carolina State University, Raleigh.

Rick Barrows and Ken Overturf of the ARS Small Grains and Potato Germplasm Research Unit, Hagerman, Idaho, for developing improved rainbow trout and plant-based trout feed for U.S. aquaculture.

Also of Interest

Top honors for technology transfer efforts that represent five to 15 years of sustained achievement went to the Canal Point Sugarcane Variety Selection Team for transferring high yielding sugarcane varieties to the Florida sugarcane industry and internationally transferring variety selection methods, disease screening and diagnostic procedures to growers and scientists in Central America.

Team members included Jack Comstock, Serge Edmé, Barry Glaz, Neil C. Glynn, Duli Zhao, Jimmy Miller (retired), Peter YP Tai (deceased), all of the ARS Sugarcane Production Research Unit, Canal Point, Fla.; and outside partners R. Wayne Davidson, of the Florida Sugar Cane League, Clewiston, Fla.; Robert Gilbert, Ronald Rice, and Leslie Baucum, all of the University of Florida, Belle Glade and LaBelle; James M. Shine, Jr., of the Sugar Cane Growers Cooperative, Belle Glade; Raul Perdomo, Gerald Powell, Barney Eiland, and Modesto Ulloa, all of Florida Crystals Corp., West Palm Beach, Fla.; and Michael S. Irey and Chen-Jian Hu, both of the United States Sugar Corp., Clewiston, Fla.

Selected for superior technology transfer efforts in the sustained achievement category were:

Benjamin Matthews, ARS Soybean Genomics and Improvement Laboratory, Beltsville Md., for the development of "MiniMax," a cultivar developed specifically for research and education, and associated growing and transformation procedures.

Larry Stanker, ARS Foodborne Contaminants Research Unit, Albany, Calif., for development of monoclonal antibody technology to detect the antibiotic ceftiofur and its metabolites in milk.

The ARS Forage and Range Research Laboratory, Logan, Utah, for developing and transferring plant materials that conserve, restore and increase productivity on western rangelands and pastures. Team members included Jack E. Staub, Thomas Jones, Kevin Jensen, Kay Asay (retired) and Douglas Dewey (deceased).

Newly Found Genes May Lead to Nematode-Resistant Upland Cotton

U.S. Department of Agriculture (USDA) researchers have made significant progress in finding genetic resistance to two key cotton pests—the root-knot nematode and the reniform nematode.

Agricultural Research Service (ARS) plant geneticist Johnie Jenkins and his colleagues in the agency's Genetics and Precision Agriculture Research Unit in Mississippi State, Miss., developed genetic markers for the genes responsible for resistance to root-knot nematode in upland cotton. These genes, located on chromosomes 11 and 14, should help breeders develop new varieties of nematode-resistant cotton.

ARS is the USDA's principal intramural scientific research agency, and this research supports the USDA commitment to agricultural sustainability.

Jenkins and his colleagues also found that resistance to reniform nematode in a wild Gossypium barbadense line is governed by more than one gene, and they have identified markers linked to these genes on chromosomes 21 and 18. Their research was published in Theoretical and Applied Genetics. Former post-doctoral researcher Osman Gutierrez (currently a plant geneticist at the ARS Subtropical Horticulture Research Station in Miami, Fla.), was lead author on the paper. Co-authors included agronomist Jack McCarty, molecular geneticist Martin Wubben, and plant physiologist Franklin Callahan, all with ARS at Mississippi State, and retired ARS scientist Forest Robinson at College Station, Texas.

Commercial breeders had steered away from efforts to breed root-knot nematode resistance into upland cotton lines over the years because the resistance

was governed by more than one gene and seemed too costly and time-consuming. But the research contributions from Jenkins and his colleagues may change that.

The root-knot nematode has been recognized as a cotton pest for the past 100 years, according to Jenkins. Since the 1930s, scientists have been looking for resistance to nematodes. In the 1960s, ARS started research to find root-knot nematode resistance in cotton. Retired ARS scientist Raymond Shepherd was instrumental in using root-knot nematode resistance in a line of wild cotton from Mexico to develop resistant germplasm.

New, Fresh-Market Blueberries Available for Southern Production

Growers and consumers alike stand to benefit from Gupton and Pearl, two new southern highbush blueberry cultivars developed by U.S. Department of Agriculture (USDA) researchers in Poplarville, Miss.

In addition to high yields of plump, flavorful berries and vigorous growth, the new cultivars should give southern growers a jump on the lucrative, early-ripening fresh market, which starts in April and May.

According to Stephen Stringer, a geneticist with USDA's Agricultural Research Service (ARS), there's been limited acreage of southern highbush blueberries because their lack of vigor has made them difficult to grow. Gupton and Pearl are different because they were derived from crosses made among southern highbush germplasm with improved adaptation to the southeastern United States, says Stringer. He's with the Thad Cochran Southern Horticultural Research Laboratory, which is operated in Poplarville by ARS, the USDA's chief intramural scientific research agency.

Stringer collaborated on the cultivars' development, testing and release with ARS horticulturists Donna Marshall and James Spiers (retired) and ARS small-fruits breeder Arlen Draper (retired).

In Mississippi field trials, Gupton and Pearl flowered in mid to late April and were ready for harvest approximately 21 days before the earliest ripening rabbiteye cultivars, the predominant type grown in the South. The highbush cultivars produce firm, medium-to-large berries with light blue color and a high soluble-solids content, among other desirable traits. The cultivars themselves grow as cone-shaped, upright shrubs and have a chilling requirement (necessary for springtime blooms) of 400 to 500 hours at temperatures below 45 degrees Fahrenheit.

Gupton, released in 2006, and Pearl, released in 2010, are finding their way into crop fields and nurseries as more propagative material becomes available from tissue-culture operations and softwood cuttings. Several nurseries have requested Pearl, and some Mississippi growers already have planted Gutpon in small commercial plots, Stringer reports.

Michigan, Maine, New Jersey and other northern states lead U.S. production, but year-round demand for the antioxidant-rich berry has given southern growers a chance to get a bigger piece of the action—especially the early-ripening fresh market, for which southern highbush blueberries are ideally suited.

Using a Universal Pathway to Whack at Weeds

A U.S. Department of Agriculture (USDA) scientist in Oxford, Miss., is working toward developing new herbicides by focusing on a molecular pathway that not only controls weeds, but could have helped shape our nation's history.

Also of Interest

Franck Dayan, a plant physiologist with the USDA's Agricultural Research Service (ARS) Natural Products Utilization Research Unit in Oxford, is an expert on a class of weed killers known as "PPO herbicides," which choke off the weed's ability to make chlorophyll. Many weeds are developing resistance to glyphosate, the world's most widely used herbicide, and alternatives are needed.

ARS is USDA's principal intramural scientific research agency, and the research supports the USDA priority of promoting international food security.

Much of Dayan's work focuses on ring-shaped pigment molecules known as porphyrins (pronounced POR-fer-ins) that "bind" or react with different metals and perform vital functions in both plants and animals. A key step in porphyrin synthesis is performed by an enzyme (protoporphyrinogen oxidase or PPO), and disrupting the PPO enzyme can cause problems in plants and animals.

In humans, disruption is associated with a congenital disease known as porphyria, with symptoms that may include sensitivity to light, seizures, and other neuropsychiatric problems. In plants, PPO herbicides work by disrupting the enzyme's production of porphyrins and inhibiting photosynthesis. PPO herbicides have been around for decades and are specifically designed so they will only disrupt PPO enzyme activity in plants and not in humans.

Dayan recently published a report on the role PPO enzymes play in triggering resistance to PPO herbicides in waterhemp *(Amaranthus tuberculatus)*, a common weed. He and his colleagues compared the molecular structure of PPO enzymes in resistant and susceptible water hemp. The results confirmed that deletion of a single amino acid, known as glycine 210, caused structural changes in the enzyme binding site that allows waterhemp to develop herbicide resistance. The work, published in the journal *Biochimica et Biophysica Acta,* built on previous research showing waterhemp's resistance capabilities. Understanding the resistance mechanisms should lead to better herbicides.

In another report, Dayan described the diverse roles played by porphyrins and PPO enzymes as essential components of life on earth. The article in *American Scientist* notes that life couldn't exist without them, and recounts how scholars have argued that a case of porphyria in King George III may have contributed to our nation's struggle for independence.

Nematodes with Pest-Fighting Potential Identified

Formosan subterranean termites could be in for a real headache. U.S. Department of Agriculture (USDA) scientists have identified species of roundworms, or "nematodes," that invade the termite brains and offer a potential bio-based approach to controlling them. Other nematodes that were identified invaded tarantula brains.

The Formosan termite, a nonnative species from Asia, feeds on cellulose from the heartwood of trees, the wood support beams of buildings, and other sources. It causes an estimated $1 billion annually in U.S. damages, repairs and control costs.

Biologically based control of the pest isn't a new concept, but the nematode species examined thus far do not kill the termites efficiently, according to Lynn Carta, a plant pathologist with the Nematology Laboratory, operated in Beltsville, Md., by the Agricultural Research Service (ARS), USDA's chief intramural scientific research agency.

Since 1999, Carta has determined the identities of seven species of nematode isolated from the bodies of Formosan termites by Ashok Raina, a retired entomologist formerly with the ARS Southern Regional Research Center in New Orleans, La. Other specimens Carta has identified were collected from dead or sick termites native to Uzbekistan.

Further details appear in the *International Journal of Nematology.*

Of particular interest to Carta and colleagues are bacteria that have a symbiotic association with the nematodes. In one case, a *Poikilolaimus* nematode species and bacterial "accomplice" were isolated from the heads of Formosan termites, and it's likely the microbe had sickened the insects in the field. According to Carta, the bacterial association raises an interesting prospect: using nematodes as vectors of insect pathogens rather than as primary biocontrol agents—the traditional approach.

In another case that's still under investigation, Carta implicated a *Panagrellus* nematode species in the death of pet tarantulas. She suspects an insect and yeast may also be involved and is intrigued by the possibility because it would reveal a new ecological association that could yield novel approaches to pest control.

Beneficial Mold Packaged in Bioplastic

Aflatoxins are highly toxic carcinogens produced by several species of *Aspergillus* fungi. But not all *Aspergillus* produce aflatoxin. Some, in fact, are considered beneficial. One such strain, dubbed K49, is now being recruited to battle these harmful *Aspergillus* relatives, preventing them from contaminating host crops like corn with the carcinogen.

In collaboration with University of Bologna (UB) scientists in Italy, U.S. Department of Agriculture (USDA) scientists Hamed Abbas and Bob Zablotowicz (retired) have devised a new method of applying K49 as a frontline defense against aflatoxin contamination in corn, which causes an estimated $200 million annually in U.S. losses alone.

K49 is known as non-toxigenic (atoxigenic) because it cannot produce aflatoxin, unlike toxigenic strains of *A. flavus* and *A. parasiticus* that do. However, K49 is adept at excluding these aflatoxin-producing (toxigenic) "cousins" from ecological niches and resources that both need to survive. Exploiting this rivalry, called bio-competitive exclusion, offers an effective way to diminish aflatoxin levels in soil and in corn kernels.

Abbas is a plant pathologist and lead scientist with the Biological Control of Pests Research Unit, operated in Stoneville, Miss., by the Agricultural Research Service (ARS), USDA's chief intramural scientific research agency. This research supports the USDA priority of ensuring food safety.

Unlike the wheat and barley grains now used as carriers to apply commercial strains of biocompetitive *Aspergillus* molds, Abbas and UB colleague Cesare Accinelli encapsulated K49 in bioplastic granules made of corn starch and other environmentally friendly ingredients.

According to Abbas, the bioplastic granules improve the beneficial mold's storage life and viability once applied. And because wheat and barley grains are not used as carriers, seed-hungry animals like rats and birds avoid eating the bioplastic granules, giving K49 a chance to release its spores for dispersal to corn plants via wind or insect activity.

In tests, applications of the bioplastic-coated K49 reduced aflatoxin levels by 65 to 97 percent. The scientists' research was published in 2011 in the journal *Crop Protection.* The technology may also prove useful in delivering other beneficial fungi used to safeguard crops from disease, adds Abbas.

Minimizing Mining Damage with Manure

U.S. Department of Agriculture (USDA) research confirms that the time-tested practice of amending crop soils with manure also can help restore soils on damaged post-mining landscapes.

Also of Interest

Thousands of acres of land with little or no vegetation, once mined for lead and zinc, remain throughout an area of southwestern Missouri, southeastern Kansas, and northeastern Oklahoma. The mining activities also left behind a legacy of lead-contaminated acidic soils, toxic smelter sites, and large quantities of mine tailings called "chat."

Soil scientist Paul White at the Agricultural Research Service (ARS) Sugarcane Research Unit in Houma, La., was part of a team that studied whether adding beef manure compost to soil at post-mining sites would provide the carbon needed to support a healthy plant cover. The scientists also wanted to determine if the compost could reduce levels of lead and zinc that could contaminate runoff during heavy rain. ARS is USDA's chief intramural scientific research agency.

The team amended soils in experimental plots from the mine sites with 20 or 120 tons of beef manure compost per acre, and established a cover crop of switchgrass on all the plots. Then they took soil samples from the sites five times during the two-year study.

Two years after the study began, soils in the high-compost plots had significant increases in pH, plant-available phosphorus, total nitrogen, carbon and available water. High-compost amendments also increased microbial biomass, enzyme activity and nitrification potential, all of which create and support favorable conditions for plant establishment and growth.

High rates of compost also lowered lead and zinc availability by about 90 percent, which may reduce the amount of lead and zinc that could run off and pollute nearby waterways. Since high levels of bioavailable zinc inhibit plant growth, this binding action also helps to promote the establishment of a vegetative cover that minimizes runoff and soil erosion.

The team published its findings in *Applied Soil Ecology* in 2011.

Scientists Identify Insect-repelling Compounds in Jatropha

A tip about a folk remedy plant used in India and Africa to ward off bugs has led to the discovery of insect-repelling compounds.

U.S. Department of Agriculture (USDA) scientists have identified components of *Jatropha curcas* seed oil that are responsible for mosquito repellency. Researchers at the Agricultural Research Service (ARS) Natural Products Utilization Research Unit (NPURU) in Oxford, Miss., often find effective plant-derived compounds to deter insects by gathering plants in the wild and investigating those used in traditional folk remedies. ARS is USDA's principal intramural scientific research agency.

After learning that people in India burn *J. curcas* seed oil in lamps to keep insects out of their homes and other areas, NPURU chemist Charles Cantrell extracted smoke from the plant in a laboratory and analyzed its properties. Free fatty acids and triglycerides were among a number of active compounds found to be effective at preventing mosquitoes from biting.

Researchers have known for some time that fatty acids repel insects, but this was the first known report that identified triglycerides as having mosquito repellent activity, according to Cantrell.

Working closely with colleagues at ARS and the National Center for Natural Products Research at the University of Mississippi, Cantrell is exploring additional promising compounds from other plants. By combining these or similar compounds from other plants with those in Jatropha species, scientists might be able to develop a more effective product.

2010 Mid South Area—ARS Award Winners

Area Senior Research Scientist

Karamat R. Sistani
Bowling Green, KY

For outstanding research and team leadership in using animal wastes to increase crop yields, while protecting water and air quality and controlling pathogens.

Area Early Career Research Scientist

Ryan P. Viator
Houma, LA

For identifying, conducting, and transferring research that meets current and future needs of the sugarcane industry.

Technology Transfer Award

Xiaoliang Cui
New Orleans, LA

For outstanding efforts in supporting the transfer of USDA-AMS process for cotton classification, which helped facilitate the sale of U.S. cotton to China.

2010 Federal Laboratory Consortium Awards

John Loughrin
Bowling Green, KY

Ariel Szogi
Patrick Hunt
Matias Vanotti
Florence, SC

Patricia Millner
Beltsville, MD

For "Second Generation Treatment System for Management of Livestock Manure," a cost effective method for the treatment of livestock waste that is an alternative to open lagoons, the dominant method of treating hog waste in the country.

2011 Mid South Area—ARS Award Winners

Area Senior Research Scientist

Gillian Eggleston
New Orleans, LA

For developing and transferring technologies that prevent postharvest bacterial deterioration of sugarcane and sugar beet and increasing the efficiency of sucrose processing. Also, **2010 Federal Laboratory Consortium—Southeast Region Excellence in Technology Transfer Award** for enhanced application of Dextranases in sugarcane and sugar beet processing.

Area Early Career Research Scientist

Julia Wei Pridgeon
Auburn, AL

For inventing vaccines to protect fish against bacterial diseases.

Technology Transfer Awards

Kim Daigle
Fred Shih (retired)
New Orleans, LA

For developing "Choice Batter," a rice-based frying batter sold nationwide.

2011 Federal Laboratory Consortium—Southeast Region Excellence in Technology Transfer Award

Agnes M. Rimando
Oxford, MS

For developing "Health Benefits of Pterostilbene."

2012 Mid South Area—ARS Award Winners

Area Senior Research Scientist

Franck Dayan
Oxford, MS

For scientific leadership and sustained research productivity on the mode of action of natural products and on their development as natural herbicides.

Area Early Career Research Scientist

Kim Cook
Bowling Green, KY

For creative research program investigating fastidious microbial populations important to human, animal, and environmental health.

Technology Transfer Awards

Bob Danka
Jeff Harris
John Harbo (retired)
Baton Rouge, LA

Tom Glenn
Suki Glenn
Glenn Apiaries
Fallbrook, CA

For the enhanced utilization of honey bees possessing Varroa sensitive hygiene traits for the purpose of protecting the production of national food supply. Also, **2011 Federal Laboratory Consortium—Southeast Region Excellence in Technology Transfer Project of the Year Award** for "Honey Bees with Varroa Sensitive Hygiene."

2012 Federal Laboratory Consortium—Southeast Region Excellence in Technology Transfer Awards

Method for Encapsulation of Microparticles

Xixuan Jin
Stoneville, MS

Dan Custis
President of Advanced Biological Marketing, Inc.
Van Wert, OH

Robert B. Elliott
Biological Control of Pests Research Unit
Stoneville, MS

In Vivo Production of Entomopathogenic Nematodes

Juan A. Morales-Ramos
M. Guadalupe Rojas
Stoneville, MS

David I. Shapiro-Ilan
Byron, GA

W. Louis Tedders
President of Southeastern Insectaries, Inc.
Perry, GA

ARS Science Hall of Fame Inductees from the Mid South Area

WILSON A. REEVES — Inducted 1987

Wilson A. Reeves worked as chief of the Cotton Finishing Laboratory in New Orleans, Louisiana. He developed individually and with other scientists many economically beneficial techniques for making cotton and cotton-blend fabrics flame resistant, flame retardant, wash-and-wear, and durable press. Reeves' research and leadership in the field of textile chemical finishing has significantly benefited agriculture and consumers.

EDGAR E. HARTWIG — Inducted 1988

Edgar E. Hartwig developed new soybean cultivars that helped transform this crop to the second most valuable U.S. crop. During the 1960's, 70's, and 80's, nearly 90 percent of southern soybean acreage was planted with cultivars developed by Hartwig. He worked as a research agronomist at ARS' Soybean Production Research Unit in Stoneville, Mississippi.

CHESTER G. McWHORTER — Inducted 1994

Chester G. McWhorter worked as a research leader at the ARS Application Technology Research Unit in Stoneville, Mississippi. He earned his place in the Hall of Fame for contributing to American agriculture through basic and applied research that has resulted in improved weed management technology leading to increased yields and reduced production costs. McWhorter's improved weed control technology is now used in the United States on more than 60 million acres annually.

RUTH ROGAN BENERITO — Inducted 2004

Ruth Rogan Benerito, a chemist, is recognized as one of the foremost inventors of the 20th century. Through her pivotal role in developing wrinkle-free cotton fabrics, she helped make cotton fiber competitive with synthetics. Her basic research in the physical chemistry of cellulose opened up vast potentials in the manufacture of wood and paper products as well as those made from cotton. Benerito was research leader at the Cotton Chemical Reactions Laboratory in New Orleans, Louisiana.

JOHNIE N. JENKINS — Inducted 2007

Plant geneticist Johnie Jenkins' realization of interdisciplinary teamwork on host plant resistance brought great advances in reduction of damage to cotton by insects and nematodes. Investigating differences in germplasm resistance to pests, he pioneered the understanding of the effects of chemical differences among cotton strains on the variability of damage done by pests. Cotton farmers can thank Jenkins for less damage by boll weevils, *Heliothis,* tarnished plant bugs, and root-knot nematodes. Jenkins also performed seminal work on cotton fruiting, retention, and yield, developing the technique of "plant mapping."

Mid South Area Contacts

Office of the Director

U.S. Department of Agriculture
Agricultural Research Service
Jamie Whitten Delta States Research Center
141 Experiment Station Road
P.O. Box 225
Stoneville, MS 38776-0225
Phone: (662) 686-5265
Phone: (662) 686-3000 (inquiries)
Fax: (662) 686-5309
Web address: www.ars.usda.gov/msa

ALABAMA

Aquatic Animal Health Research Laboratory, Auburn

The unit helps solve major health problems in aquaculture that diminish the productivity and quality of farm-raised fish. The unit develops vaccines, diagnostics tests, and special diets that help prevent fish diseases and parasites.
Phone: (334) 887-3741 Fax: (334) 887-2983

National Soil Dynamics Research Laboratory, Auburn

The laboratory develops tools, practices, and products to better manage soil for sustainable and profitable agricultural production. It solves agricultural problems in conservation systems, organic waste management, and global change.
Phone: (334) 887-8596 Fax: (334) 887-8597

KENTUCKY

Forage-Animal Production Research Unit, Lexington

Research is to enhance forage-based livestock production systems through biochemical and molecular genetic research of the forage plant and grazing animal. Research supports the management of grasslands as a vast renewable resource in the Southeast and Appalachia and sustains agricultural income for producers throughout the area.
Phone: (859) 257-1647 Fax: (859) 257-3334

Animal Waste Management Research Unit, Bowling Green

Research is to develop and evaluate management practices and treatment technologies that protect water quality, reduce air emissions, and control pathogens at animal production facilities, manure storage areas, and field application sites. The unit conducts solution-oriented research that aid farmers and livestock producers in cost effectively solving problems associated with animal waste in an environmentally sound manner considering the unique problems associated with karst topography. Solutions are expected to be effective, economically reasonable, and managerially realistic for the farmers and the livestock producers. It is also expected that the research results will reduce potential hazards to the public without undue economic hardship to the farmers/producers.
Phone: (270) 781-2260 x 221 Fax: (270) 781-7994

LOUISIANA

Sugarcane Research Unit, Houma

Research focuses on research-solutions that enhance the viability of sugarcane as a sugar and/or biofuels feedstock. This is accomplished by utilizing a multidisciplinary approach to develop improved varieties and environmentally friendly production strategies that will insure profitability, expand the cropping range, and combat a constantly evolving pest complex that includes diseases, insects, and weeds.
Phone: (985) 872-5042 Fax: (985) 868-8369

Honey Bee Breeding, Genetics, and Physiology Research Unit, Baton Rouge

Research deals with improving honey bee stock and honey bee management as well as solving problems caused by varroa mites and tracheal mites. Researchers engage in breeding and testing honey bees for resistance to mites, evaluating mite-bee interactions to better describe breeding criteria, and evaluating stock production processes to explore and solve stock problems caused by mites.
Phone: (225) 767-9280 Fax: (225) 766-9212

Southern Regional Research Center (SRRC), New Orleans

This center is one of four major ARS Research Centers in the United States. Research deals with postharvest processing, product enhancement, and new uses of agricultural commodities.
Phone: (504) 286-4214 Fax: (504) 286-4234

The following six entities are part of the Southern Regional Research Center:

Commodity Utilization Research Unit, New Orleans

Research focuses on the design and development of improved or innovative, cost-effective, and environmentally friendly technologies that produces enhanced or value-added products from agricultural crops.
Phone: (504) 286-4511 Fax: (504) 286-4367

Cotton Chemistry and Utilization Research Unit, New Orleans

Research leads to development of value-added products, applications, and processes for U.S. cotton.
Phone: (504) 286-4541 Fax: (504) 286-4390

Cotton Fiber Bioscience Research Unit, New Orleans

Research seeks to increase quality attributes of cotton fiber, such as strength and length, through discovery, characterization, and manipulation of cotton fiber specific genes using new tools in biotechnology.
Phone: (504) 286-4528 Fax: (504) 286-4250

Cotton Structure and Quality Research Unit, New Orleans

The unit develops and improves the methods for assessing quality and structural attributes of cotton fiber through all stages of production and processing, from field to fabric.
Phone: (504) 286-4407 Fax: (504) 286-4217

Food and Feed Safety Research Unit, New Orleans

Research enhances the wholesomeness, safety, and economic competitiveness of U.S. food and feed crops.
Phone: (504) 286-4388 Fax: (504) 286-4533

Food Processing and Sensory Quality Research Unit, New Orleans

The unit develops technologies that optimize the nutritional, functional, and sensory qualities of agricultural commodities, thus enhancing their utilization.
Phone: (504) 286-4451 Fax: (504) 286-4430

MISSISSIPPI

Crop Science Research Laboratory, Mississippi State

The laboratory studies insect and disease resistance of crops; examines the molecular processes of cotton and corn; develops site-specific, precision agricultural technologies and systems and develops better ways of managing animal waste, including poultry and swine waste, in the mid-southern United States.
Phone: (662) 320-7386 Fax: (662) 320-7528

The following two research units are part of the Crop Science Research Laboratory:

Corn Host Plant Resistance Research Unit, Mississippi State

This unit provides increased, more efficient production of food and feed crops with enhanced food safety in the southeastern United States through genetics and breeding of corn, particularly for the reduction of aflatoxin.
Phone: (662) 325-2735 Fax: (662) 325-8441

Genetics and Precision Agriculture Research Unit, Mississippi State

This unit expands knowledge of the genetics and molecular processes of cotton, of the biology and behavior of selected cotton pests, of site-specific precision agricultural cotton production practices, and develops better ways to manage waste from the production of poultry and swine.
Phone: (662) 320-7387 Fax: (662) 320-7528

Poultry Research Unit, Mississippi State

This unit improves poultry health and production efficiency. Disease, engineering, management, nutrition, and rearing environment research are conducted with a multi-disciplinary approach.
Phone: (662) 320-7479 Fax: (662) 320-7589

National Sedimentation Laboratory, Oxford

Research program focuses on soil erosion, transport and deposition of sediment, and chemical movement in upland areas and streams that affect water quality and the ecological well-being of streams.
Phone: (662) 232-2901 Fax: (662) 232-2915

The following two research units are part of the National Sedimentation Laboratory:

Watershed Physical Processes Research Unit, Oxford

This unit develops improved methods to measure, control, and predict erosion and sediment yield from fields, streams, and impoundments in agricultural watersheds and water management practices and systems that improve water availability for agriculture. Research emphasizes the physical processes controlling runoff generation; sheet and rill erosion; gully erosion; streambank failure; stream channel erosion; transport and deposition of sediment; state of the art electronic and acoustic assessment technologies; and modeling technologies that evaluate management practice effectiveness in controlling runoff and erosion at field, channel, and watershed scales.
Phone: (662) 232-2975 Fax: (662) 281-5706

Water Quality and Ecology Research Unit, Oxford

The unit develops basic and applied science to protect and enhance soil and water resources and ecosystem functions within watersheds affected by agricultural activities. Research goals are to (a) develop and assess farm and land management technologies that reduce erosion and nutrient losses, conserve soil, and protect ecological resources; (b) improve understanding of structure, function, and key processes of aquatic systems, guiding better management of these systems and providing a scientific basis for regulatory agencies to establish water quality criteria and standards; and (c) assemble and use long-term databases to develop, validate, and enhance computer models quantifying effects of conservation measures on agricultural watershed ecosystem services.
Phone: (662) 232-2908 Fax: (662) 232-2915

Natural Products Utilization Research Unit, Oxford

The unit develops natural products for uses in agriculture in order to produce more toxicologically benign pest management tools and to improve the nutriceutical value of crops. Additionally, this unit also conducts research to aid in the development of alternative crops for production of pharmaceutical and botanical supplements.
Phone: (662) 915-1034 Fax: (662) 915-1035

Southern Horticultural Research Unit, Poplarville

The unit focuses on development of cultural practices, pest management strategies, and cultivars that improve small fruit, vegetable, and ornamental plant production in the Gulf Coast States.
Phone: (601) 403-8750 Fax: (601) 795-4965

Biological Control of Pests Research Unit, Stoneville

The unit conducts fundamental research on the production and use of biological control agents of agricultural and urban pests, in partnership with industry whenever feasible. Emphasis is placed on development of novel, efficient mass rearing methods including technology for harvesting, packaging, storage, and distribution of quality-assured biological control agents. Related research is also conducted on the improvement and implementation of regional fire ant management programs.
Phone: (662) 686-5487 Fax: (662) 686-5281

Catfish Genetics Research Unit, Stoneville

This unit's focus is to determine the inheritance of economically important traits in catfish, determine genotype x environment interactions, improve catfish health through selective breeding, develop and evaluate genetically improved lines for release to commercial production, and conduct research on pond production problems to improve water quality and production efficiency. Research will be accomplished through an applied breeding program that incorporates new biotechnologies and addresses all areas of quantitative and qualitative genetics, reproduction, molecular and cellular genetics, and bioinformatics.
Phone: (662) 686-3597 Fax: (662) 686-3567

Cotton Ginning Research Unit, Stoneville

The unit develops and evaluates new ginning technologies that address efficiency, energy utilization, and fiber quality related to changing cotton varieties, production practices, harvesting methods, and mill technologies.
Phone: (662) 686-3093 Fax: (662) 686-5235

Crop Genetics Research Unit, Stoneville

The unit conducts research on the genetics, physiology, and diseases of cotton and soybeans to increase yield and quality in these crops through improved genetics and resistance to pests.
Phone: (662) 686-5241 Fax: (662) 686-5218

Crop Production Systems Research Unit, Stoneville

The unit has a comprehensive interdisciplinary research program addressing major problems of crop production in Mid South. The mission is to provide information on the development of: improved crop production systems; irrigation technology; agrochemical application technology; characterize and manage herbicide resistance; develop principles and practices for more efficient control of weeds in agronomic crops; and address soil and water resource issues.
Phone: (662) 686-5222 Fax: (662) 686-5422

Genomics and Bioinformatics Research Unit, Stoneville

This unit's focus is to coordinate and facilitate genomics and bioinformatics research emphasizing the Mid South Area, but it also interacts with other ARS scientists and research cooperators. The unit serves as a research resource for genomics technology and bioinformatics analysis of organisms

of importance to the Mid South Area such as cotton, soybean, corn, rice, sugarcane, cattle, catfish, honeybees, and specialty crops such as blueberry and sweet potato providing access to state-of-the-art instrumentation and skilled technical support for genome sequencing and bioinformatics.
Phone: (662) 686-5353 Fax: (662) 686-5372

Southern Insect Management Research Unit, Stoneville

The unit generates new knowledge of arthropod pest biology, ecology and management and integrates this knowledge into contemporary farming systems that promote economical and environmentally stable pest management practices for the southern United States. The unit's vision is to be a recognized center of innovation for negating agricultural pest problems through deployed scientific knowledge of pest biology, ecology, and management options.
Phone: (662) 686-5231 Fax: (662) 686-5421

Delta Human Nutrition Research Program, Stoneville

Research is focused on identifying dietary patterns and developing strategies for reducing obesity in the Lower Mississippi Delta population through nutrition and behavioral intervention.
Phone: (225) 892-3662 Fax: (662) 686-5309

Worksites

Food and Feed Safety Research Unit, Tucson, AZ

Research is primarily aimed at large scale treatment of biocontrol agent to control aflatoxin contamination in affected crops.
Phone: (520) 626-5049 Fax: (520) 626-5944

Soybean Disease and Nematology Research Project, Jackson, TN

The focus of this unit is to develop germplasm with a broad range of resistance to the soybean cyst nematode and other diseases of soybeans.
Phone: (731) 426-0420 Fax: (731) 425-4760

Watershed Physical Processes Research Unit, Jonesboro, AR

This unit develops improved methods to measure, control, and predict erosion and sediment yield from fields, streams, and impoundments in agricultural watersheds. Research emphasizes the physical processes controlling detachment, transport, and deposition of sediment; state-of-the-art electronic and acoustic assessment technologies; and mathematical descriptions that quantify the impacts of management alternatives.
Phone: (870) 819-2708 Fax: (662) 281-5706

Facilities in the ARS Mid South Area

Jamie Whitten Delta States Research Center, Stoneville, MS

National Biological Control Laboratory, Stoneville, MS

Crop Science Research Laboratory, R.W. Harned Building, Mississippi State, MS

Crop Science Research Laboratory, R.W. Harned Building, Mississippi State, MS (back side of building greenhouses)

National Sedimentation Laboratory, Oxford, MS

Thad Cochran Southern Horticultural Laboratory, Poplarville, MS

Sugarcane Research Unit, Houma, LA

New facilities at Ardoyne Farm, Sugarcane Research Unit, Houma, LA

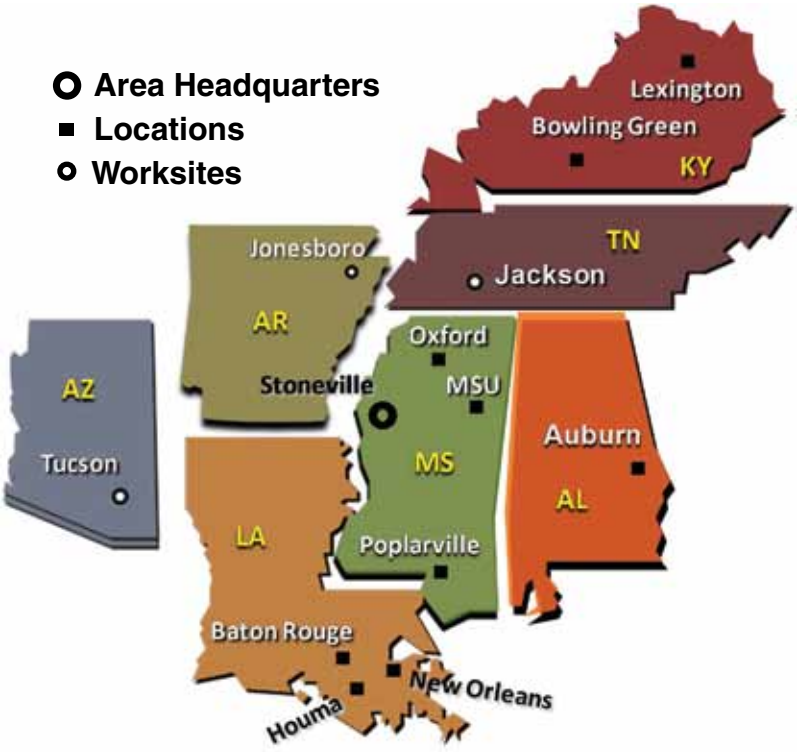
Honey Bee Breeding, Genetics, and Physiology Research Unit, Baton Rouge, LA

Southern Regional Research Center, New Orleans, LA

Aquatic Animal Health Research Unit, Auburn, AL

National Soil Dynamics Laboratory, Auburn, AL

Animal Waste Management Research Unit, Bowling Green, KY



Mid South Area

Office of the Director
U.S. Department of Agriculture
Agricultural Research Service
Jamie Whitten Delta States Research Center
141 Experiment Station Road
P.O. Box 225
Stoneville, MS 38776-0225
Phone: (662) 686-5265
Phone: (662) 686-3000 (inquiries)
Fax: (662) 686-5309
Internet: www.ars.usda.gov/msa