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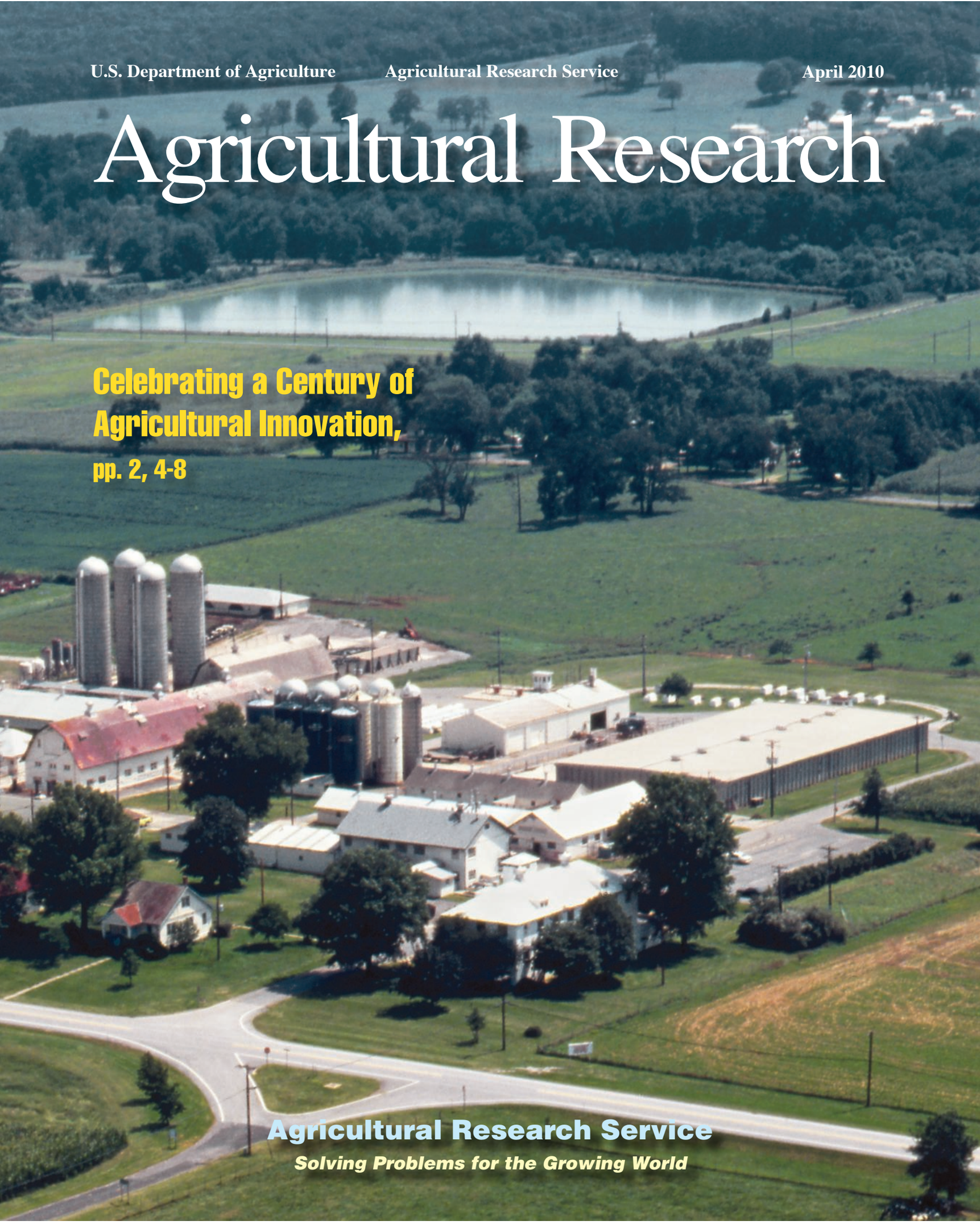
Agricultural Research

Celebrating a Century of Agricultural Innovation,

pp. 2, 4-8



Agricultural Research Service

Solving Problems for the Growing World

FORUM

At BARC, We've Only Just Begun

There's an easy way to keep an eye on what we're up to at the Beltsville Agricultural Research Center (BARC) these days. The Agricultural Research Service has around 900 active, appropriated research projects across the country, and a detailed description of each project is posted on the ARS website. And according to the in-house database we use for tracking our work, about 250 BARC researchers are either heading up or collaborating with more than 100 of these projects.

Reading through these BARC projects is like reading through the course list at a university for overachievers. In the Environmental Management and Byproduct Utilization Laboratory, researchers are taking on a study called "Air Quality in the Chesapeake Bay Region as Influenced by Agricultural Land Use Changes." Down the road at the Sustainable Agricultural Systems Laboratory, their colleagues have put together a project entitled "Molecular Approaches To Enhance Plant Nutrient Content, Shelf-Life, and Stress Tolerance." Scientists in the Bovine Functional Genomics Laboratory are tackling "Using Genomics To Define and Control Parasitic Infections in Cattle." And ARS experts at the Bee Research Laboratory have been working steadily at "Improving Honey Bee Health, Survivorship, and Pollination Availability"—work that's been carried out in a spotlight since 2006, when beekeepers began reporting alarming losses in their hives from colony collapse disorder.

For an agricultural research facility that started out in 1910 with a single dairy barn, we've done pretty well over the years. Of course, we got a big boost in the 1930s, when some of the men in the Civilian Conservation Corps (CCC)—one of the New Deal programs that put people back to work during the Great Depression—came to Beltsville to expand our space. When they were done,

KEN HAMMOND (K9638-2)

Aerial view of the Dairy Research Facility and surrounding area on the east side of BARC, circa 1994.

they had constructed 21 buildings, erected 242 miles of fencing, and built 79 miles of roads, trails, and bridges. They had also landscaped 500 acres, moved 78,000 trees and shrubs, and installed 126 miles of water, sewer, and drainage pipes. In addition, they used blueprints that had been drawn up for lodging in Yellowstone National Park to build the rustic "Log Lodge," which served as a recreation center for CCC workers in the area. The Log Lodge now provides a home for the ARS National Visitor Center, which was visited in 2009 by around 5,000 people, including government officials, stakeholders, schoolchildren—and the occasional local resident who wanted help in identifying a mysterious insect.

So where do we go next?

U.S. Department of Agriculture Secretary Tom Vilsack has outlined his research priorities for USDA scientists and collaborators. He wants us to find out more about how farming practices affect the dynamics of global climate change. He wants us to concentrate on finding ways to improve our detection of pathogens that cause foodborne illness and ways to keep those pathogens from contaminating our food supplies. Scientific studies on enhancing health and nutrition throughout childhood is another mandate, as is research on creating food security, both in the United States and across the globe. Finally, Secretary Vilsack firmly believes that USDA scientists can significantly contribute to the development of environmentally sustainable systems for bioenergy production that will help secure abundant—and homegrown—supplies of "green" energy.

BARC is the world's largest agricultural research complex, and our scientists will be front and center in these efforts. We have the tools and expertise to decipher the genetic workings of a single soybean and the instruments to measure and analyze data on all the factors—including fertilizer inputs, available sunlight, rainfall, temperature, slope aspect, soil type, planting and harvest schedules, and pest-control strategies, among others—that affect crop production and yield.

We've traced the evolution of *Toxoplasma gondii*, a parasite that has for 10 million years infected warm-blooded vertebrates around the globe, to acquire the information needed to mitigate its future impacts on livestock and humans. Our nutritional investigations have revealed not only how Americans eat, but what they can choose to eat if they want to improve their health with every bite. Our scientists confirmed what many of us had already found out through bitter experience: that poison ivy is thriving and becoming even more virulent because of rising global temperatures. We're working on ways to predict the best crops to grow along the eastern seaboard as the U.S. population increases and available farmland dwindles. We've even found a way to make biodegradable flowerpots out of chicken feathers.

It could be that our first hundred years at BARC are only the beginning and that our best is yet to come. Meanwhile, if you're in the neighborhood on June 5, please join us at our Centennial Celebration Field Day, when we'll take a look at where we've been and talk a bit more about where we intend to go from here.

Joseph Spence
BARC Area Director
Beltsville, Maryland

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Agricultural Research

Solving Problems for the Growing World

Cover: This year marks the 100th anniversary of the Henry A. Wallace Beltsville Agricultural Research Center. Some of the center's many accomplishments are highlighted in a photo journal that begins on page 4. This aerial photograph features the Dairy Research Facility on the east side of BARC, circa 1994. Photo by Ken Hammond. (K9638-2)

IN THE NEXT ISSUE

FEEDING THE WORLD—The abundance found in a typical U.S. supermarket might make it hard to believe, but hunger and nutrient deficiencies still plague millions of people worldwide. Pests, pathogens, and changing weather patterns jeopardize both crops and livestock. ARS recognizes the need to stay several steps ahead of these threats to our food security. The next issue of the magazine takes a look at research targeted toward improving rice, beans, wheat, corn, and potatoes—the crops that truly do feed the world.

Celebrating 100 Years of Beltsville

For the Henry A. Wallace Beltsville Agricultural Research Center (BARC), the year 2010 marks a significant moment in its history. The arrival of BARC's 100th anniversary is a time to commemorate past research successes, celebrate current research efforts, and anticipate future endeavors.

But this celebration is not just for BARC alone; it's a celebration for all of the Agricultural Research Service. You see, much of the research currently being conducted by ARS labs around the country originated at BARC. For example, Daniel E. Salmon and his assistants were the first to isolate and discover *Salmonella* bacteria in pigs. In 1910, they were asked to continue their *Salmonella* research with USDA at the newly formed BARC. Now, a century later, ARS labs in Albany, California; Ames, Iowa; Athens, Georgia; Clay Center, Nebraska; College Station, Texas; and Wyndmoor, Pennsylvania, have joined BARC in continuing the research started by Salmon to help USDA remain a leader in *Salmonella* research.

Even before BARC's official formation in 1910, its scientists were on the cutting edge of agriculture. Charles V. Riley, the top entomologist for USDA until 1894, was the first to practice biological pest control by introducing the Vedalia beetle from Australia to control scale on citrus.

Of course, Riley's research wasn't conducted on BARC's current campus. It was conducted at USDA's first location on the National Mall in Washington, D.C. USDA also had other experimental farms and research stations located close by in Virginia and Maryland. In 1910, USDA's purchase of the Walnut Grange plantation in Beltsville marked the beginning of BARC. Surrounding land and buildings were later purchased to house more research laboratories, and the experimental farms and research locations were moved to Beltsville.

Large-scale expansion, however, didn't occur until the 1930s, during the Great Depression. Then-Secretary of Agriculture Henry A. Wallace believed that research was the best way to advance agriculture and preserve the environment. Thanks to him, BARC now sits on about 7,000 acres and remains a world leader in agricultural research.

Throughout the past 100 years, there have been numerous agricultural breakthroughs made by BARC scientists. Here in this photo journal, we highlight just some of those accomplishments. If BARC's history is any indicator of its future, we'll see many more discoveries in the next 100 years.—By **Stephanie Yao,** ARS.

More information about the Beltsville Agricultural Research Center can be found at www.ba.ars.usda.gov. ✸

STEPHEN AUSMUS (K11275-2)

BARC is the largest, most diversified agricultural research complex in the world. Research is conducted through programs at the U.S. National Arboretum, the Animal and Natural Resources Institute, the Beltsville Human Nutrition Research Center, and the Plant Sciences Institute.

1920s

PEGGY GREB (D1448-3)

BARC researchers solve a major food problem: the short shelf life of butter. They show that using pasteurized sweet cream instead of sour ripened cream helps butter last longer. Nowadays, ARS researchers in Beltsville, Maryland; Peoria, Illinois; Wyndmoor, Pennsylvania; Albany, California; and New Orleans, Louisiana, are looking at ways to improve the shelf life of many foods.

1930s

KEITH WELLER (K8753-1)

BARC scientists produce the first successful vaccine to immunize cattle against brucellosis, a serious disease that causes high incidences of abortions, among other effects. Elk (above) are reservoirs of the disease, which is transmissible to other animals and humans. Brucellosis research continues at ARS laboratories in Ames, Iowa.

1950s

TIM McCABE (K2282-7)

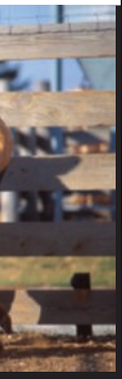
Throughout the decade, scientists release a steady stream of new varieties of fruits and vegetables with enhanced disease resistance, better flavor, and other desirable traits. ARS laboratories all over the country continue this work.

Agricultural Research

SPECIAL COLLECTIONS, NAL (J HORACE McFARLAND COLLECTION D1741-1)

1920s

In 1924, BARC researchers release Mary Wallace, the first shrub rose that is also multi-disease resistant. Named after the daughter of the Secretary of Agriculture, this rose is voted in 1928 the most popular rose in the United States. Today, ARS researchers at the U.S. National Arboretum and in Poplarville, Mississippi; Corvallis, Oregon; and Miami and Fort Pierce, Florida, continue to develop plants with desirable traits.



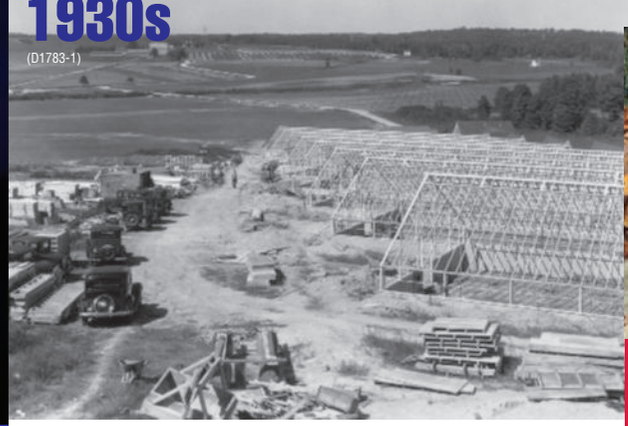
1930s

KEITH WELLER (K9834-1)

After determining the role of vitamin A in maintaining sight, researchers determine adults should consume a minimum of 5,000 to 6,000 international units of vitamin A per day. Later, in the 1970s, scientists at the Beltsville Human Nutrition Research Center discover that supplementing vitamin A with zinc helps prevent blindness. ARS has five other human nutrition centers in Boston, Massachusetts; Houston, Texas; Grand Forks, North Dakota; Davis, California; and Little Rock, Arkansas.

1930s

(D1783-1)

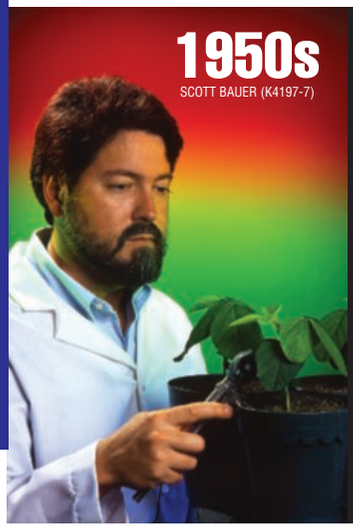


Many government agencies began as part of USDA and were located in Beltsville. The list includes the U.S. Food and Drug Administration, the U.S. Environmental Protection Agency, the U.S. Geological Survey, and the USDA Forest Service. Other agencies—the National Aeronautics and Space Administration, the U.S. Department of Commerce, and the Office of Naval Research—also conducted research projects on USDA land in Beltsville. Collaborative research between USDA and other agencies continues today.

A new group of pesticides safer for humans—DEET, DDT, rotenone, and allethrin—help keep soldiers safe from insects and the diseases they spread. To this day, ARS continues to work with the U.S. military to solve problems.

1940s

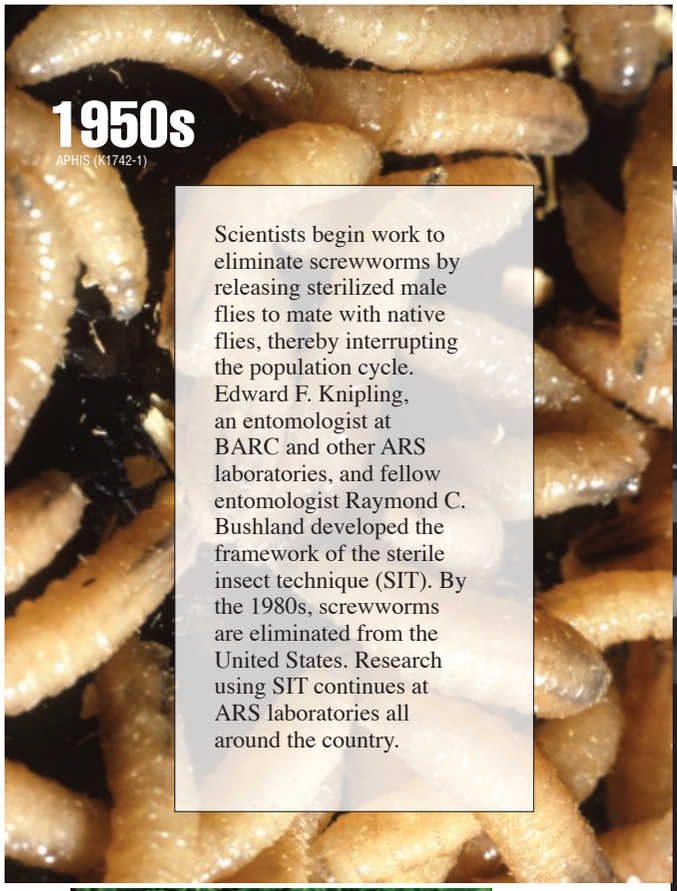
SCOTT BAUER (K7243-7)



1950s

SCOTT BAUER (K4197-7)

Photoperiodism (discovered in 1918) shows that flowering in plants is controlled by changes in day length. In the 1950s, BARC scientists discover phytochrome, a dual-form plant protein that determines when a plant will start, or put off, flowering. This serves as a core concept in plant physiology in labs all around the country today.



1950s

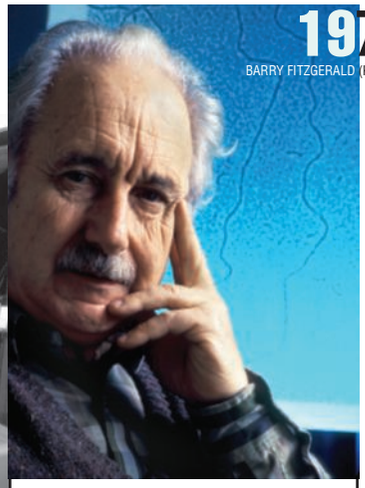
APHIS (K1742-1)

Scientists begin work to eliminate screwworms by releasing sterilized male flies to mate with native flies, thereby interrupting the population cycle. Edward F. Knipling, an entomologist at BARC and other ARS laboratories, and fellow entomologist Raymond C. Bushland developed the framework of the sterile insect technique (SIT). By the 1980s, screwworms are eliminated from the United States. Research using SIT continues at ARS laboratories all around the country.

1960s

FRED WITT (K9635-1)

BARC agricultural engineer Karl Norris develops the first computerized near-infrared spectrophotometer. This noninvasive technique measures numerous traits without destroying the sample. Today it is used to help keep our food supply safe and ensure the quality of many of our commodities.



1970s

BARRY FITZGERALD (K3146-1)

Plant pathologist Theodore O. Diener discovers the viroid, the smallest known agent of plant disease. His discovery is ranked among the top 10 milestones for plant pest and pathogen research by the American Phytopathological Society.

1990s

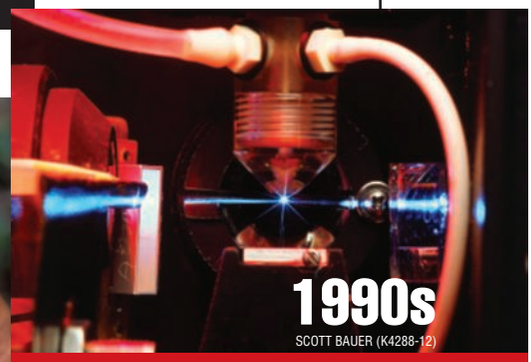
SCOTT BAUER (K7814-2)

In the 1990s and 2000s, breeding and selection at the U.S. National Arboretum leads to the introduction of 10 elm cultivars resistant to Dutch elm disease, which nearly wiped out the entire U.S. elm tree population in the 1940s. Scientists also introduce six red maple cultivars with symmetrical forms, long-lasting fall color, and insect tolerance.

1990s

SCOTT BAUER (K8618-1)

Working with industry counterparts, BARC scientists discover in 1999 a fungus that inhibits a devastating disease on cacao trees. This finding could help save the $8.6 billion U.S. chocolate industry, which depends entirely on imported chocolate.



1990s

SCOTT BAUER (K4288-12)

BARC researchers develop technology to separate X- and Y-bearing sperm in animals, allowing sex selection of offspring and contributing to better breeding practices.

The Germplasm Resources Information Network (GRIN) is established as the world's most comprehensive database of agriculturally important plants. BARC scientists direct USDA plant exploration all over the world. Germplasm that is collected is maintained in ARS collections throughout the country.

1980s

(K1563-2)

Researchers start using remote sensing from satellite images to detect nutrient deficiencies in crops and environmental conditions such as soil erosion. They also develop models to help determine efficient use of land and water, crop yield forecasting, and drought assessment.

1980s

(K1165-2)

1980s

SCOTT BAUER (K7246-1)

Studies show that decreasing dietary animal fat and increasing the portion of fat from vegetable sources significantly lowers blood pressure in people having high blood pressure.

2000s

SCOTT BAUER (K9314-2)

In 2001, BARC researchers develop the first transgenic cow, named "Annie," with resistance to mastitis. The disease is caused by *Staphylococcus aureus* bacteria that destroy milk-secreting cells in the animal's mammary gland. Mastitis costs U.S. dairy farmers about $1.7 billion annually, including lost milk revenues.

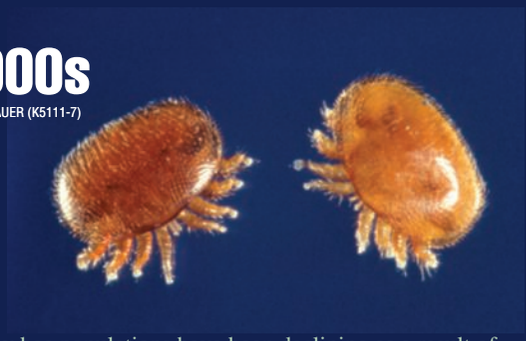
2000s

STEPHEN AUSMUS (D1480-1)

In 2002, as part of an agreement with the nonprofit Horticulture Research Institute, scientists begin research to create a nonpetroleum-based biodegradable plastic plant container made from biowaste products. In 2009, scientists release the first biodegradable flowerpot made from discarded chicken feathers. The nursery industry uses about 1 billion pounds of plastic containers per year, and waste from these containers is generally not recyclable.

2000s

SCOTT BAUER (K5111-7)



Honey bee populations have been declining as a result of parasites and diseases. In 2000, BARC developed a screened-bottom-board insert for bee hives that helps reduce the number of parasitic *Varroa* mites. In 2005, scientists received U.S. Food and Drug Administration approval for an antibiotic to control American foulbrood, one of the most destructive and widespread bee diseases.

SCOTT BAUER (K9076-1)

2000s
SCOTT BAUER (K8295-1)

In efforts to improve the health of the Chesapeake Bay, BARC researchers work with federal and Maryland state government agencies to improve the implementation of winter cover crop programs. They develop remote sensing technology for landscape-scale monitoring of the effectiveness of cover crops to sequester nutrients and keep them from washing into the bay.

Over the past 100 years, scientists with the U.S. National Arboretum have developed and released more than 650 cultivars for the floral and nursery plants industry, an $8 billion industry nationwide. Fifteen of these cultivars are Gold Medal or All-America Selection winners.

2000s
STEPHEN AUSMUS (D887-2)

BARC scientists develop a method for measuring individual trans fats in foods. This method has a broad use in food analysis and subsequent labeling of foods. BARC research in humans shows that trans fats raise serum cholesterol, leading to the recent U.S. Food and Drug Administration requirement for food labels to show trans fatty acid content.

2000s
KEITH WELLER (K8148-9)

2009
PEGGY GREB (D1526-1)

BARC scientists use the sequence of the cow genome to predict milk production in dairy cows with three times higher accuracy and at one-twentieth of the cost. They are also now able to provide the information at birth rather than at 5 years of age. This technology has revolutionized the dairy industry in just 1 year.

2010
PEGGY GREB (D674-3)

Issues affecting agriculture, such as climate change and decreases in available resources, pose significant challenges in the coming years. As we aim to find solutions to these problems, BARC will continue to be a leader in agricultural research every step of the way.

Diverse Wheat Tapped for Antifungal Genes

Asian wheat may offer novel genes for shoring up the defenses of U.S. varieties against *Fusarium graminearum,* the fungus that causes *Fusarium* head blight (FHB), ARS studies suggest.

Several *Fusarium* species cause FHB worldwide, but in the United States the most problematic to wheat (and barley) is *F. graminearum*. For example, an epidemic that swept through the Great Plains from 1998 to 2000 cost America's wheat industry $2.7 billion in losses.

Guihua Bai, a plant molecular geneticist in ARS's Hard Winter Wheat Genetics Research Unit, Manhattan, Kansas, is working to prevent a repeat disaster by broadening the suite of FHB-resistance genes now available to U.S. wheat.

According to Bai, only a few resistant sources are used in wheat breeding programs—the Chinese wheat variety Sumai 3 among them. But the fungus is an adaptable foe, and there's concern that FHB-causing species will overcome resistant sources like Sumai 3. Bai and colleagues at Kansas State University-Manhattan have sought new sources of resistance from exotic wheat lines collected from China, Korea, and Japan. These lines include old "landrace" populations—domesticated plants that have changed little since the advent of modern plant breeding.

In greenhouse trials, the researchers inoculated the Asian wheats with *F. graminearum* spores and compared their responses to seven commercial varieties, including the resistant Sumai 3 and the susceptible Wheaton.

Of 87 total Asian accessions tested, 26 showed high levels of FHB resistance. Grain evaluations revealed that 15 accessions had exceptionally low levels of the fungal toxin deoxynivalenol, which is produced during disease development and can reduce the value of affected kernels as food or feed.

Six of the resistant accessions possessed genes for three different forms of FHB-resistance, known as types I, II, and III. "Some of these genes appear unrelated to those in Sumai 3," says Bai. This work suggests that the Asian lines could indeed add depth to the genetic pool of resistance now available for breeding U.S. wheat varieties.

Using genomic tools, Bai's team has begun hunting for molecular markers (small pieces of DNA used in diagnostic tests) to speed identification of other novel resistance sources and top-performing offspring of crosses made between resistant germplasm and elite commercial varieties.

On a related front, the team also worked to better characterize the three types of FHB resistance. Type I, which manifests as barriers to initial infection, may be least accessible to wheat breeders. "Type II is resistance to the spread of FHB symptoms in a wheat spike, and it appears to highly correlate with type III—low levels of the toxin," Bai says. Thus, he adds, selecting for type II resistance should be a top priority when breeding for overall resistance to FHB.—By **Jan Suszkiw,** ARS.

GUIHUA BAI (D1733-1)

A Chinese resistant wheat line (right) and a U.S. susceptible wheat line (left) were inoculated with the *Fusarium* head blight pathogen. The susceptible line became infected while the resistant line stayed healthy.

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

Guihua Bai is in the USDA-ARS Hard Winter Wheat Genetics Research Unit, Grain Marketing and Production Research Center, 4008 Throckmorton Hall, Kansas State University, Manhattan, KS 66506; (785) 532-1124, guihua.bai@ars.usda.gov. ✸

PEGGY GREB (D1710-1)

New Ideas for Longer Lasting Blooms Blossom in California Laboratory

The white areas on these normally purple-colored petunias are the result of a research technique called "virus-induced gene silencing" (VIGS). Researchers are using the technique to quickly determine the function of genes involved in flower longevity.

Maybe you've experienced the frustration of picking out the perfect bouquet or potted plant, only to have its attractive blossoms wither and droop just a few days later.

Help may be on the way.

Floriculture research from the laboratory and greenhouse of plant physiologist Cai-Zhong Jiang might help growers, retailers, and you boost the vase life of your favorite cut flowers and extend the shelf life of your prized potted plants.

Jiang is with ARS's Crops Pathology and Genetics Research Unit at Davis, California, about 75 miles northeast of San Francisco.

With co-investigators from the University of California-Davis (UCD) and the Universities of Florida and Reading (United Kingdom), Jiang is experimenting with a number of practical tactics to forestall plants' natural aging, called "senescence." In longer-term research, he's digging into the underlying causes, or gene-controlled mechanisms, of aging. Such probing may eventually lead to discoveries of how to modify flowers' aging-linked genes or the proteins that are products of those genes.

In one series of studies, Jiang, UCD colleague Michael S. Reid, and co-researchers have shown that spraying low concentrations of a commercially available compound known as thidiazuron (TDZ), short for N-phenyl-N'-(1,2,3-thiadiazol-5-yl)urea, has what Jiang describes as "significant, sometimes spectacular, effects" in extending the life of potted plants' leaves and flowers. For example, in tests with greenhouse-grown cyclamen plants, TDZ-treated plants "had a longer life than unsprayed plants—more than a month longer," he says.

Importantly, TDZ sprays, added to water and applied in concentrations of 5 to 10 parts per million, didn't play havoc with the shape of the plants. That's important, because disfigurement is a common and unwanted side effect of some other compounds commonly used commercially to offset aging of blooming plants, Jiang points out.

TDZ, a synthetic version of a naturally occurring plant hormone known as a "cytokinin," is not new. Perhaps surprisingly, it's used in higher concentrations to cause cotton plants to drop their leaves so that mechanical harvesters can more easily pluck the plants' fluffy white bolls. But preliminary studies with cut flowers, reported by Reid and co-researchers in 2000, showed that smaller doses of the defoliant extended the life of alstroemeria leaves. The study was the first to demonstrate the value of TDZ for a commercial floricultural species. The cyclamen experiments conducted by Jiang and his collaborators are the first to show the leaf-saving and blossom-boosting effects of TDZ with potted floricultural plants.

Though commercial, after-harvest use of the compound—on cut flowers and potted plants—seems promising, the researchers' deeper interest lies in determining precisely how TDZ affects genes and proteins inside the plants. "We want to understand exactly how TDZ works," says Jiang. Ideally, the research would yield innovative strategies to make TDZ even more effective with today's most popular ornamental species. What's more, the

Spraying low concentrations of TDZ can have significant

CAI-ZHONG JIANG (D1738-1)

Potted cyclamen plants treated with TDZ (left) stay fresh significantly longer than untreated plants.

Technician Linda Donnelly examines the effects of silencing functionally unknown genes to determine their influence on petunia flowers' longevity.

–sometimes spectacular–effects on flower longevity.

studies may determine how to sidestep the nonresponsiveness of some popular potted plants to TDZ. One example: Jiang and teammates want to determine why TDZ helps maintain freshness of some kinds of miniature potted roses, but not others.

Identifying Genes That Cause Aging

Meanwhile, another approach is already teasing out some clues about genes of interest. Known as "virus-induced gene silencing," or VIGS, this technique allows scientists to determine the function of genes in senescing plants. The scientists insert a gene, or genes, of interest into the naturally occurring tobacco rattle virus. Next, in laboratory experiments, the researchers expose plants to the virus. Doing that triggers the plants' natural defense mechanism, which includes attempting to quash, or silence, the invader virus. When that happens, the gene or genes that scientists inserted into the virus are also silenced. By comparing the VIGS plants with those not exposed to the retooled virus, scientists may be able to determine the silenced gene's function.

In proof-of-concept experiments, Jiang, Reid, and co-investigators used petunia as their model plant and showed that inserting a piece of a color-imparting gene into the virus resulted in white splotches or sectors on a normally purple-flowering petunia. "We tricked the plant's defense system into squelching the gene's normal job of creating color," explains Jiang. A second gene fragment that the team also inserted into the virus was similarly silenced in the oddly white sectors. That silenced gene would normally have been involved in producing ethylene, an aging compound. But white sectors on the virus-infected plants produced less ethylene than plants not exposed to the virus, the researchers found.

"The basic idea here is that we can use the virus as a tool to quickly turn off genes, to see which ones control senescence," says Jiang. Though used elsewhere to study senescence in tomato and barley, the experiments by Reid, Jiang, and colleagues are the first to use VIGS to explore senescence mechanisms in commercially grown cut flowers and potted plants.

In studies reported in the 2009 book *Petunia: Evolutionary, Developmental, and Physiological Genetics,* the scientists indicate that the technique can be used to study as many as five independent genes in a single experiment. That's an invaluable timesaver, especially since two of their targets, known as "NAC" and "MADS box transcription factor" genes, act as master switches, each controlling many other genes in the so-called senescence network.

In all, the investigations may result in new, economical, and environmentally friendly ways to extend the life of cut flowers and potted plants. It's research that could prolong the beauty and vitality of cherished plants and our enjoyment of them, as well.—By **Marcia Wood,** ARS.

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

Cai-Zhong Jiang is in the USDA-ARS Crops Pathology and Genetics Research Unit, 1 Shields Ave., Davis, CA 95616; (530) 752-7060, caizhong.jiang@ars.usda.gov. ✸

Figuring Out Puzzling Animal Diseases

Animal disease research sometimes follows a predictable path of discovery, identification, test availability, and finally, prevention or cure. But other times, the path becomes a long and winding road. ARS scientists at the Animal Diseases Research Unit (ADRU) in Pullman, Washington, are working to put together the pieces of some tough-to-solve animal disease puzzles.

Bison Viral Infection Tough To Control

Malignant catarrhal fever (MCF)—a viral infection that is a leading cause of disease in American bison—is usually transmitted from sheep to bison and cattle. Vaccine development has been stymied because the virus will not grow in cell culture.

Microbiologist Hong Li, veterinary medical officer Naomi Taus, and others at ADRU, in collaboration with Lindsay Oaks at Washington State University and Donal O'Toole at the University of Wyoming, have discovered that the reason the virus won't grow in cell culture is that it undergoes several changes inside the animal's body. It targets specific cell types at different stages of its life cycle—a process called "cell tropism switching."

The viral replication cycle in sheep can be divided into three stages: entry, maintenance, and shedding. When entering sheep through the nasal route, the virus reaches the lung, where it replicates exclusively. Replication in sheep lung is required for the virus to change its cell tropism for the next stage—infecting lymphocytes, a type of immune cell. In this maintenance stage, the virus stays in the lymphocytes, circulating through the whole body with little replication. This type of infection is referred to as a "latent infection." During the shedding stage, the virus reactivates from the infected lymphocytes, targets specific cells in the nasal turbinates to complete its replication, and is then shed through sheep nasal secretions.

PEGGY GREB (D1730-1)

Veterinary microbiologist Hong Li selects MCF virus-free sheep for a viral replication study.

PEGGY GREB (D1729-1)

A sheep from a flock established and maintained to be free of MCF and OPP viruses.

"Amazingly, the virus replicated in turbinate cells is not capable of reinfecting turbinate cells because it changes its cell tropism again," Li says.

This type of presto-chango trickery has been very effective at keeping the virus in circulation. "It also explains why it has been impossible to grow in cell culture—it's like trying to grow one organism in a cell culture designed for another organism," Li says. With the knowledge of how the virus replicates in sheep, scientists can now begin to find the right cell types to grow the virus in cell culture.

Closer to a Vaccine

Until such a culture becomes available, Li and his colleagues are exploring alternative avenues of developing a vaccine to protect bison and cattle from MCF. Working with colleagues from the USDA Animal and Plant Health Inspection Service's National Veterinary Services Laboratories, the group plans to use a particular MCF virus strain present in hartebeest and topi (African antelopes) that does grow in culture.

"The topi MCF virus does not cause disease in cattle (and hopefully not in bison). We are trying to insert genes from the sheep MCF virus into the topi virus in an effort to create a vaccine to protect bison and cattle from getting MCF," says Li. "Even though a vaccine isn't around the corner, we're much closer to

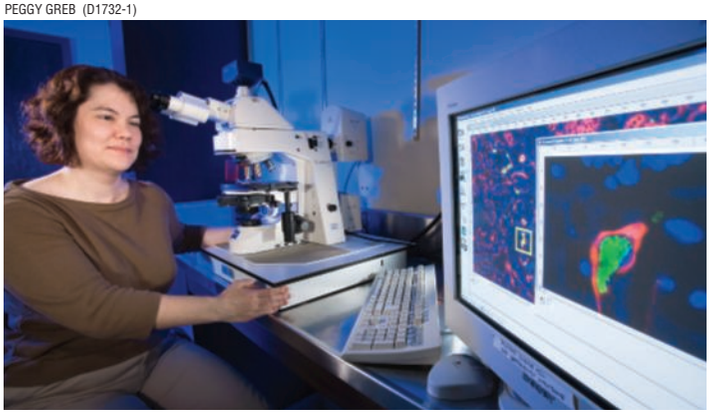
one than we were 5 years ago. Until a vaccine is developed, spatial separation is the only way to prevent infection in bison."

Using Genetics To Diagnose and Predict Disease

Another ruminant disease being investigated by scientists at ADRU is ovine progressive pneumonia virus (OPPV), which causes mastitis, respiratory distress, swelling of the knees (arthritis), and wasting in infected sheep. One in two U.S. sheep of open-range flocks are infected with OPPV, and it is believed to be mainly transmitted between adult sheep through respiratory secretions. OPPV slowly erodes producers' profits over the years by lowering average weaning weights of lambs and the average number of lambs produced.

The current method to control OPPV is to test sheep blood for either antibodies to the virus or OPPV concentration and then separate infected sheep from uninfected sheep. The problem is that many infected sheep never develop clinical disease symptoms. Says microbiologist Lynn Herrmann-Hoesing, "An OPPV test that predicts or determines which infected sheep will then go on to display clinical disease is highly sought."

PEGGY GREB (D1732-1)



Veterinary medical officer Naomi Taus examines an MCF virus-infected epithelial cell in a sheep lung. The red area is the virus, and the green area is the cell.

Herrmann-Hoesing and geneticist Stephen White, in close collaboration with Michelle Mousel and Gregory Lewis of ARS's U.S. Sheep Experiment Station in Dubois, Idaho, are evaluating two different tests: One is a quantitative PCR test using real-time technology, and the second is an immunogenetics test.

"With one or both of these tests, we hope to provide a diagnostic method that determines or predicts whether the sheep will progress to OPPV clinical signs," says Herrmann-Hoesing. "In addition, these types of tests have the potential to significantly reduce the number of other tests necessary for determining infection and possibly lower the transmission potential in a flock. Therefore, these new tests offer significant long-term economic advantages for the producer over conventional serological diagnostic tests."

PEGGY GREB (D1731-1)

Technician Shirley Elias (left) and veterinary medical officer Naomi Taus use a nebulizer to infect a sheep with MCF virus.

Diagnostic testing of sheep can be expensive since current recommendations are to test annually or biannually for at least 5 years to ensure OPPV-negative flock status.

Animal diseases are a fact of life for livestock producers, but with improved diagnostic and therapeutic tools being investigated by ARS scientists, the well-being of food animals can be better managed and economic risks for the producers can be limited.—By **Sharon Durham,** ARS.

This research is part of Food Animal Production (#101) and Animal Health (#103), two ARS national programs described at www.nps.ars.usda.gov.

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PEGGY GREB (D1728-1)

Animal care manager Emma Karel (left) and microbiologist Lynn Herrmann-Hoesing collect a blood sample from a sheep for an OPPV-related immunogenetic analysis.

PEGGY GREB (D1714-2)

Geneticist Craig Ledbetter examines the nuts of a self-pollinating almond selection in a California test plot.

Self-Pollinating Almonds Key to Bountiful Harvests

California has more than 600,000 acres of almond orchards. At the beginning of each new year, these almond trees burst into bloom. That's when growers will need many millions of robust bees to ferry pollen from one cream-white blossom to the next.

Hive-rental costs to almond growers are high, ranging from $125 to $180 per hive. But in the future, these costs may be avoidable because bees may no longer be needed for almond pollinating.

This possibility could prove true as a result of the work of Agricultural Research Service geneticist Craig Ledbetter, in the Crop Diseases, Pests, and Genetics Research Unit in Parlier, California. He has developed new and improved self-pollinating almond trees—ones that can produce a bountiful harvest without being pollinated by insects.

Self-pollinating almonds are not new. The Tuono variety, originally from Spain, has been around for centuries. But it has few of the characteristics that have made California almonds beloved domestically and internationally. Almond breeders will tell you that Tuono is simply not as attractive as California's most popular almond, Nonpareil, because Tuono has a hairy texture to the seed coat.

"You can feel that hairiness with your tongue," says Ledbetter. "That can turn off U.S. almond consumers, who are used to the smooth texture of Nonpareils."

Another strike against Tuono—it has a very thick, hard shell, so only 32 percent of the nut is edible kernel. Nonpareil, however, is 60 to 65 percent kernel.

One good thing about Tuono's thick shell is that it gives the nut more resistance to the dreaded navel orangeworm, the primary pest of almonds in California. At Parlier, an areawide integrated pest management program is under way to reduce navel orangeworm damage and broad-spectrum insecticide use throughout the San Joaquin Valley. The program is being led by Joel Siegel, assisted by fellow entomologists Bas Kuenen and Chuck Burks.

PEGGY GREB (D1720-1)

A fifth instar navel orangeworm larva infesting a Nonpareil almond.

PEGGY GREB (D1719-1)

Adult navel orangeworm *(Amyelois transitella)* on a Nonpareil almond.

PEGGY GREB (D1716-1)

Entomologist Chuck Burks (right) bags almonds to exclude navel orangeworm while entomologist Joel Siegel hangs a pheromone dispenser to disrupt the pest's mating. These techniques are part of an integrated pest management program under way in the San Joaquin Valley.

Eight Great Almond Selections

Though both Tuono and Nonpareil almonds have their strong points, the ideal almond would have the best traits of each. In 1993, Ledbetter started his work to breed a desirable self-pollinating almond. Seedlings were first planted in 1996 and every year thereafter.

Tuono was used as the male (pollen) parent in conventional hybridizations with California-adapted almond cultivars and selections. Ledbetter and his team made the crosses at bloom time and came back at harvest time to collect the nuts. The scientists grew out those nuts into seedlings and then surrounded the branches with insect-proof nylon bags to exclude insects that could serve as pollinators. The seedlings bloomed, and some produced fruits inside the bags. The scientists knew that these seedlings were the self-pollinators, because no foreign pollen had been introduced into the bags.

At first, harvests from the seedlings were small, but by 2006 the trees began producing excellent harvests. In November 2008, after a very good fall almond harvest, Ledbetter and his Parlier team brought eight very promising self-pollinating selections to the California Almond Board for evaluation of taste and appearance. The testers were pleased with the skin color, oil content, and—most importantly—the flavor. The new almonds have many of the same characteristics of Nonpareil, which has been grown in California since the 1880s and accounts for 37 percent of all almonds grown in the state.

"What separates the Parlier-developed selections and Nonpareil, of course, is that these ARS almond trees need no external pollination," said Ledbetter. "Ours is a very good-looking kernel that's very comparable to that seen in Nonpareil."

Shells Snare Chemicals From Water

In other work, Ledbetter is working with Thomas Klasson, research leader at ARS's Commodity Research Unit in New Orleans, Louisiana, to test the adsorption ability of almond shells. Parlier is near Fresno, and as in many other cities, there are concerns about water quality. In Fresno's case, those concerns date back to World War II, when chemicals from cleaning military aircraft from the city's air base entered the groundwater supply. Use of agricultural nematicides—chemical pesticides used to kill parasitic nematodes—in orchards and vineyards around Fresno for many decades has also harmed water quality in the area's aquifer.

To purify this water, granular activated carbons (GACs) were put to use to adsorb the chemicals. Fresno has 35 GAC sites alone, each using a minimum of 20,000 pounds of granulated carbon.

In California, more than 1.3 billion pounds of almond meat is produced every year, but much of the almond shells from those nuts goes to waste. Ledbetter and Klasson have been working together for the past 2 years to see whether this mass of almond-shell carbon could be used in these mammoth municipal city GAC vessels. In laboratory testing, almond-shell carbons have proven to have high adsorption ability. Testing in a larger vessel will be done in the upcoming years.—By **Alfredo Flores,** 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.

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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.

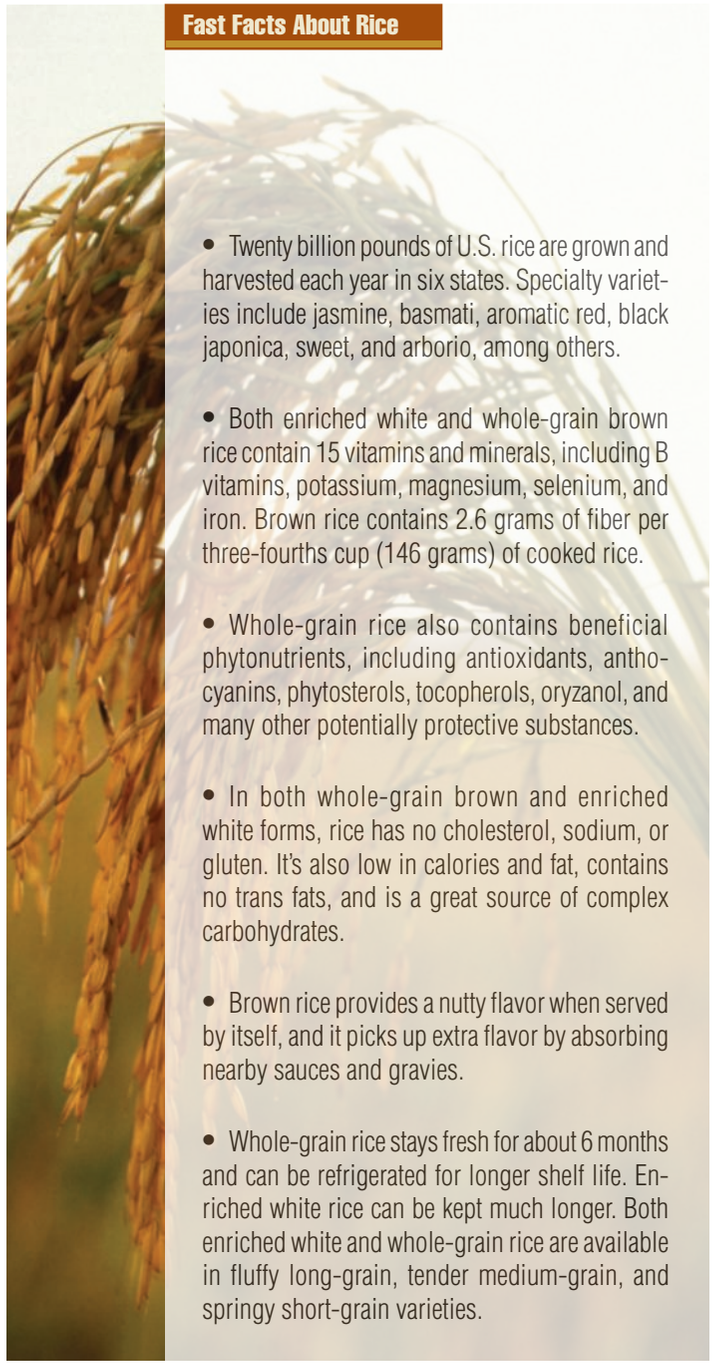
Champagne and Banville assembled several experts on these starches for the 2009 workshop, "Exploring the Health-Promoting Functions of Rice Starch and Protein," including ARS chemist Ming-Hsuan Chen with the ARS Rice Research Unit in Beaumont, Texas.

"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.



Fast Facts About Rice

- Twenty billion pounds of U.S. rice are grown and harvested each year in six states. Specialty varieties include jasmine, basmati, aromatic red, black japonica, sweet, and arborio, among others.
- Both enriched white and whole-grain brown rice contain 15 vitamins and minerals, including B vitamins, potassium, magnesium, selenium, and iron. Brown rice contains 2.6 grams of fiber per three-fourths cup (146 grams) of cooked rice.
- Whole-grain rice also contains beneficial phytonutrients, including antioxidants, anthocyanins, phytosterols, tocopherols, oryzanol, and many other potentially protective substances.
- In both whole-grain brown and enriched white forms, rice has no cholesterol, sodium, or gluten. It's also low in calories and fat, contains no trans fats, and is a great source of complex carbohydrates.
- Brown rice provides a nutty flavor when served by itself, and it picks up extra flavor by absorbing nearby sauces and gravies.
- Whole-grain rice stays fresh for about 6 months and can be refrigerated for longer shelf life. Enriched white rice can be kept much longer. Both enriched white and whole-grain rice are available in fluffy long-grain, tender medium-grain, and springy short-grain varieties.

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.

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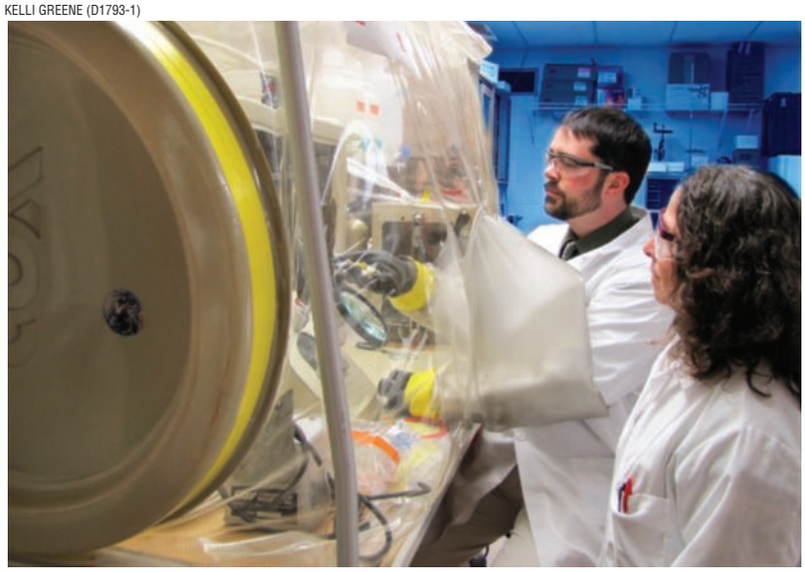
Hops Could Reduce Ammonia Production in Cattle

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.

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.

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

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"Skip Planting a Row or Two" Is Good Advice for Some

Many grain farmers in the arid central Great Plains should skip planting every one or two rows to stabilize corn yields.

This recommendation stems from a 3-year study with corn in 23 field trials across Nebraska and into western Kansas and northeast Colorado. Merle Vigil, a soil scientist at the ARS Central Great Plains Research Station in Akron, Colorado, participated in the study with 13 university and extension researchers.

"Plant two-skip two" stabilizes yields the most in the driest years and should be considered the best scheme during extreme drought. But "plant one-skip one" resulted in the highest mean yield of all planting systems tested, over average weather conditions, and many times exceeded both the standard technique and "plant two-skip two." Vigil had similar results with sorghum.

For many farmers, in a climate that goes from dry to drier, the range of possible grain yields is too large and unpredictable with standard spacing. The skip-row technique narrows the range of yields, cutting off the lowest yields as well as the highest. The narrower the range of yields, the more stable they are and the less risk involved.

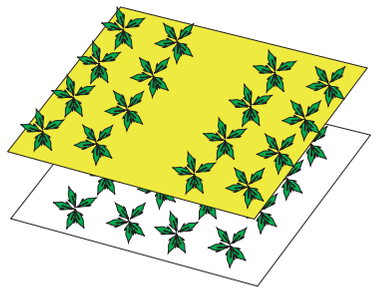
Skipping a row or two allows some of the soil water accumulated between crop rows to remain as a reserve for when the crop needs it later. For corn, it provides water during the critical flowering period.

Early in the corn-growing season, roots easily reach and deplete water that is about 30 inches away, between rows, but they can't as easily deplete water farther away.

Vigil says, "The benefits of skip-row planting should be considered by all dryland corn growers in the central Great Plains west of 101 degrees longitude, except for those with potential for more than 100 bushels an acre.

"More specifically," he says, "farmers with field histories of 75 bushels or less could choose either 'plant two-skip two' or 'plant one-skip one.' Those with yield potential between 75 and 100 bushels an acre may not see a benefit from skip-row planting."—By **Don Comis,** ARS.

Merle F. Vigil is with the USDA-ARS Central Great Plains Research Station, 40335 County Road GG, Akron, CO 80720; (970) 345-0517, merle.vigil@ars.usda.gov. ✷



Partnering With the NRC

When conducting risk-assessment studies for commercial nuclear facilities, the U.S. Nuclear Regulatory Commission (NRC) must be able to assess the movement of radioactive material in the environment. So Agricultural Research Service soil scientists Timothy Gish, Yakov Pachepsky, and Andrey Guber partnered with NRC researchers to evaluate and improve the accuracy of subsurface contaminant transport models.

The team set up their study at the ARS Beltsville Agricultural Research Center in Beltsville, Maryland, at a site that is equipped with remote sensing gear and other instrumentation for monitoring a range of geophysical and biophysical processes. This site—the Optimizing Production Inputs for Economic and Environmental Enhancement (OPE3) study area—was set up in 1998 to study major environmental and economic issues facing U.S. agriculture.

The researchers wanted to assess how the vadose zone—the zone between the soil surface and the groundwater zone—affects contaminant transport. They focused on subsurface structural features, processes, and events in the vadose zone that could drastically change the fate and transport of pollutants in a contaminant plume.

Over 2 years, the team added several nontoxic chemical tracers to irrigation water and used 12 site wells to monitor levels of those tracers at 3 different depths in the soil. Surface runoff, soil moisture profiles, soil water potential, groundwater levels, and weather variables were also monitored.

The researchers compared the field data they collected on water flow and tracer concentrations with results from model simulations. Then they applied a range of abstraction techniques to models of varying complexity to further pinpoint conditions that could significantly affect the movement of water—and contaminants—below the soil surface.

For instance, they found that tracer transport in soils and shallow groundwater could be strongly affected by gaps in the vadose zone's restrictive fine-material layers. The complex topography in this layer could cause preferential flow and transport along pathways in low parts of the surface.

Similar dynamics could direct preferential flow around natural capillary barriers and funnel subsurface flow through coarse-textured soils sandwiched between finer layers. In addition, continuous voids in fine-grained sections could also prompt rapid flow conditions.

NRC staff will be able to use the refined models to estimate pollutant transport scenarios for risk-assessment studies of nuclear facilities.—By **Ann Perry,** ARS.

Yakov A. Pachepsky is with the USDA-ARS Environmental Microbial and Food Safety Laboratory, 10300 Baltimore Ave., Bldg. 173, Room 203, Beltsville, MD 20705-2350; (301) 504-7468, yakov.pachepsky@ars.usda.gov. ✷

Niches and Glitches in Ethanol Production

STEPHEN AUSMUS (D1712-1)

Technician Greg Kennedy (left) and chemist Badal Saha sample cellulosic ethanol from wheat straw produced in a 100-liter fermenter to assess its ethanol content and to monitor how quickly the sugars in the wheat straw are being fermented into ethanol. Using the 100-liter fermenter allows the scientists to scale up the process so that they can fine-tune it and identify technical problems that might develop during large-scale ethanol production.

All plant matter, from small piles of grass clippings on the lawn to overgrown masses of kudzu enveloping entire hillsides, contains sugars that could be fermented to make cellulosic ethanol. That's why Agricultural Research Service scientists at the National Center for Agricultural Utilization Research (NCAUR) in Peoria, Illinois, are working to optimize cellulosic ethanol production and yield from the field to the fuel pump.

Since commercial cellulosic ethanol production will probably be fueled by a diverse collection of plant feedstocks, it won't be a one-size-fits-all process. Bringing commercial production online will depend on finding feedstocks that have suitable carbohydrate levels, finding cost-effective ways to free the sugars stored in those carbohydrates, and finding microorganisms that ferment all sugars.

ARS chemist Badal Saha has just wrapped up a 5-year study and concluded that wheat straw—a crop residue left over after the grain has been harvested—could have commercial potential for cellulosic ethanol production. Saha works in NCAUR's Bioenergy Research Unit.

A key step in cellulose conversion is finding effective ways to pretreat different feedstocks and break down the cell walls, where most of the sugar is stored. There is a long list of pretreatment options that use a range of chemical and physical processes, and each one has its drawbacks and benefits.

Saha found that he could access and ferment almost all the sugars in wheat straw when he pretreated it with alkaline peroxide and then used enzymes to break down the cellulose into sugars for fermentation, a process called "enzymatic saccharification." The ethanol yield was about 93 gallons per ton of wheat straw. A plus: This approach did not produce substances called "fermentation inhibitors," which sometimes develop as a result of pretreatment dynamics and reduce ethanol yield.

Pretreating wheat straw with lime also resulted in a good ethanol yield—around 83 gallons per ton of straw. As with the alkaline peroxide pretreatment, lime pretreatment didn't prompt the development of fermentation inhibitors, and it produced sugars that were easily fermented. It is also a much cheaper alternative to alkaline peroxide pretreatment.

Saha was also pleased that he obtained good ethanol yields when he combined barley straw with wheat straw. Rice hulls also showed promise as a biofuel feedstock, even though their high silica content lessened the final ethanol yield to only around 59 gallons per ton of feedstock.

Although cellulosic ethanol conversion processes often use yeast for fermentation, conventional yeast is not capable of fermenting all the sugars released from cellulosic feedstocks. So Saha worked with bacteria instead, and used a strain of *E. coli* bacterium that had been genetically enhanced to bolster its

STEPHEN AUSMUS (D1711-4)

Badal Saha and Greg Kennedy collect a sample of a fungal culture to determine whether fermentation inhibitors are present after the pretreatment of wheat straw feedstock. Inhibitors can stop or reduce the rate of ethanol fermentation.

fermentation abilities. He wanted to see if this strain could sustain good fermentation rates at industrial production levels.

"We tested the *E. coli* continuously for 4 months to ferment wheat straw," Saha says. "When we looked at the results, we didn't see any loss of bacterial productivity. The ethanol yield remained consistent throughout the study, which is a good sign that the *E. coli* can maintain good fermentation rates in prolonged production cycles."

Saha is ready to move to the next stage. "In four trials, we successfully demonstrated the conversion of wheat straw into ethanol at a 10-liter scale," he says. "Now we want to scale up to 100 liters and conduct a cost analysis of the production process."

The Sick Ward

An ethanol plant is not a pristine place. The brew of liquids, chemicals, and plant matter used to produce ethanol also gives rise to organisms that can infect the system and disrupt production until the bad guys—which are usually bacterial species that produce lactic acid—are under control.

These bacteria can grow rapidly and thrive in environments with low pH levels and relatively high alcohol levels, conditions that are both commonly found in ethanol production. The organisms fuel their growth with the plant sugars that would otherwise be fermented into alcohol. And when the bacteria usurp the sugars for their own growth, they produce lactic and acetic acids, which harm the fermenting yeast.

The result: a "stuck" fermentation. Sometimes antibiotics can take care of it, but other times, infected facilities need to be completely shut down for a thorough cleanup.

Microbiologist Ken Bischoff and geneticist Tim Leathers, who work in NCAUR's Renewable Product Technology Research Unit, have now become unofficial ethanol epidemiologists as well. "Chronic infections can reduce ethanol yields 2 to 4 percent, which is a lot at a plant that produces 100 million gallons of ethanol a year," Bischoff notes.

Leathers decided to do an identity check of the microbes that were derailing ethanol production. He collected bacteria samples from a wet-mill commercial grain-ethanol facility that had never been treated with antibiotics and from a dry-grind facility that had been dosed with antibiotics after bacterial outbreaks and was not actively infected at the time of the study. He found that most of the bacterial isolates he collected from both facilities were different types of lactic acid bacteria.

After investigating the antibiotic susceptibility of these samples, Bischoff developed a shake-flask model for simulating bacterial contamination and infection. He found that when test cultures were inoculated with *Lactobacillus fermentum*—one of the most common sources of bacterial infections in ethanol plants—ethanol yield decreased by 27 percent. The infections could sometimes be cured by treating them with virginiamycin, an antibiotic commonly used in the ethanol industry. But one strain of *L. fermentum* was already resistant to treatment.

Bischoff hopes his model can help the ethanol industry develop alternative methods to control bacterial outbreaks and improve the production process.

"Bacterial contamination is a unique niche in ethanol research," Bischoff says. "It's new, and it's an area where ARS can support the industry and really make a difference."

The research in this story supports the USDA priority of developing new sources of bioenergy.—By **Ann Perry,** ARS.

This research is part of Bioenergy and Energy Alternatives (#307) and Quality and Utilization of Agricultural Products (#306), two ARS national programs described at www.nps.ars.usda.gov.

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STEPHEN AUSMUS (D1713-2)

Microbiologist Ken Bischoff, who developed the shake-flask model for simulating bacterial infection during ethanol fermentation, places flasks in an incubator.


JACK DYKINGA (K2627-14)

Better Guidance for Battling Corn Earworm

Much of the sweet corn grown in the United States is sold as a fresh-market product, so it needs to be visually appealing to attract a buyer. Corn earworms can devastate the yield and appearance of the ear and are therefore a major concern for growers.

Adult corn earworm moths lay eggs on corn silks and on leaves, husks, and stems near the silks. After eggs hatch, larvae travel along the silks to feed on kernels, where they remain protected by the husks. *Bt* corn offers some protection against feeding by corn earworms, but some growers still conduct aerial spraying operations as often as once every 4 days to control the pest.

Bradley Fritz, an agricultural engineer at the Southern Plains Agricultural Research Center in College Station, Texas, conducted a study to see if aerial spray rates and droplet sizes make a difference in whether insecticides reach the target to control corn earworms. To be effective, the insecticides must penetrate the plant canopy and reach the silks, where larvae begin feeding soon after hatching.

Fritz sprayed test plots three times in June 2008 with insecticides approved for organic operations. He sprayed some plots with 400-micron droplets and some with 220-micron droplets. Insecticides were mixed with water at label-recommended levels and sprayed at rates of either 5 gallons or 9 gallons per acre. He and other ARS researchers then collected silks from ears of corn growing on the plots to assess how much spray actually reached the targeted silks.

Fritz's results, published in the *International Agricultural Engineering Journal,* showed that higher spray rates with larger droplets worked best to ensure the insecticide reached the targeted corn silks.

The work is part of an ARS program to optimize aerial spraying technology to control corn earworms. The results will guide future corn earworm spraying operations, and the methods may be used in future studies of spray rates for other crops and pests.—By **Dennis O'Brien,** ARS.

Bradley K. Fritz is in the USDA-ARS Areawide Pest Management Research Unit, 2771 F&B Road, College Station, TX 77845; (979) 260-9584, brad.fritz@ars.usda.gov. ✸

Subtract Pounds of Weeds, Add Pounds of Grass = More Cows

An Agricultural Research Service scientist has created an online weed calculator that tells ranchers the number of additional cows they could raise if they eliminated one or two widespread exotic invasive weeds.

Rangeland ecologist Matt Rinella, at the ARS Fort Keogh Livestock and Range Research Laboratory in Miles City, Montana, created a computer model that predicts weed impacts on forage production. Data for developing the model came from 30 weed researchers working throughout the western United States. In addition to developing the calculator so that ranchers can calculate what weeds are costing them on any given site, Rinella used the data to estimate what weeds are costing ranchers in a 17-state region. He calculated that if leafy spurge were eliminated, ranchers in that entire region could graze up to 200,000 more cows per year and save tens of millions of dollars.

Spotted knapweed is another exotic invasive weed whose elimination would greatly increase the number of cows ranches could support, and the calculator also predicts its impacts.

Interested parties can access the calculator at tinyurl.com/WeedImpact.

All the rancher needs is a datasheet, clipboard, pencil, yardstick, and homemade sampling frames of any size, rectangular or circular. The datasheets can be downloaded. Ranchers tally weeds in each frame and group them by height categories. The necessary data can be gathered in about 30 minutes.

After the numbers are entered into the calculator, the ranchers learn how many pounds of weeds they are producing per acre and how many more cattle they could raise per acre if those pounds of weeds were replaced by forage plants.

The calculator reflects a fundamental principle of integrated pest management: It is only worth controlling a pest if the profits from doing so outweigh the costs.—By **Don Comis,** ARS.

Matthew J. Rinella is with the USDA-ARS Fort Keogh Livestock and Range Research Laboratory, 243 Fort Keogh Road, Miles City, MT 59301-4016; (406) 874-8232, matt.rinella@ars.usda.gov. ✸


KEITH WELLER (K5685-1)

Science Update

Drug Eliminates Parasite That Causes Babesiosis in Horses

Equine babesiosis is caused by the blood parasites *Babesia caballi* or *B. (Theileria) equi,* both of which are transmitted by ticks. U.S. veterinarians currently use the drug imidocarb dipropionate to treat diseases like Texas fever—also known as cattle fever or babesiosis—in cattle. Researchers found that a relatively high dose of the drug eliminated *B. caballi* in horses and left the horses incapable of transmitting babesiosis. Though the high dose of the drug is generally well tolerated by horses, side effects include stomach upset and diarrhea.

In the United States, babesiosis is considered a foreign disease in horses, though it is common in nearby locales, including the U.S. territory of Puerto Rico. It is important to ensure complete parasite elimination, because infected horses that appear healthy can still transmit the disease. If approved for use in the United States, imidocarb dipropionate would offer a humane way to clear horses of *B. caballi* and potentially allow them to enter or remain in the country. *Donald P. Knowles, Animal Diseases Research Unit, Pullman, WA 99164-6630; (509) 335-6022, don.knowles@ars.usda.gov.*

Researchers Study Effect of Cinnamon Compounds on Brain Cells

When strokes or other traumatic injuries block blood flow to the brain, it can lead to fluid accumulation within brain cells or in blood vessels around the brain cells. Researchers have now found that compounds from cinnamon extracts can protect some brain cells from this type of fluid accumulation.

The scientists placed isolated glial cells, which do not carry nerve impulses but still provide essential neural support, in culture and then deprived them of oxygen and glucose for 5 hours. The cells exhibited a 40-percent decline in their membrane potential, which indicates how effectively nutrients and fluids are transported across cell membranes. After the same cells were exposed to a cinnamon extract, they regained some of the membrane potential that had been lost. In addition, the exposed cells did not show any increased fluid accumulation after the exposure to the extract, while control cells that had not been exposed continued to accumulate fluid throughout the observation period.

Further studies will be needed to determine whether cinnamon compound extracts could be helpful in treating brain trauma injuries. *Richard Anderson and Marilyn Polansky, USDA-ARS Diet, Genomics, and Immunology Laboratory, Beltsville, MD 20705; (301) 504-8091 ext. 277 [Anderson], (301) 504-9873 ext. 275 [Polansky], richard.anderson@ars.usda.gov, marilyn.polansky@ars.usda.gov.*

Springtime Sheep Grazing Helps Control Leafy Spurge

Using grazing sheep to control pasture weeds and promote desirable grasses can be more cost effective than applying herbicides and replanting pastures. Researchers used clipping treatments that mimicked grazing by sheep to study how seasonal grazing affects pasture plant communities. Results indicated that a few years of light springtime grazing can help plant communities recover after they have been infested with leafy spurge.

When leafy spurge first germinates in the spring, it draws on carbohydrates stored in the roots to support its growth. But defoliation stress prompts tannin production, which could explain why grazing triggers an eventual decline in leafy spurge levels—the carbohydrates used for tannin production are no longer available to support new growth. So even though grazing animals often avoid plants with higher tannin levels, this defensive response by leafy spurge also reduces its foliage output, which may in turn impede long-term survival. *Matthew J. Rinella, USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, MT 59301-4016; (406) 874-8232, matt.rinella@ars.usda.gov.*

(D1415-1)

Leafy spurge, *Euphorbia esula,* in blossom.

Food "Tattoos": An Alternative to Labels for Identifying Fruit

Technology called "laser etching," developed in part by ARS researchers, uses lasers to "tattoo" produce and could someday replace current labeling practices. A carbon dioxide laser beam is used to etch information into the first few outer cells of the peel on grapefruit, creating a mark that can't be peeled off, washed off, or altered in any way.

The tiny holes etched into the grapefruit peel are effectively sealed by the carbon dioxide, which prevents decay and entry by pathogens, but a coating of wax can further protect against water loss and pathogen entry. The original testing was conducted on grapefruit and has now been extended to include other citrus fruits, tomatoes, and avocados. The U.S. Food and Drug Administration is currently reviewing its application for commercial use. *Jan Narciso, Citrus and Subtropical Products Research Laboratory, Winter Haven, FL 33881; (863) 293-4133 ext. 119, jan.narciso@ars.usda.gov.*

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