

Agricultural Research

Tough and Tolerant

Crop With a Dual Function

page 12

FORUM

Mining for Phytochemicals: A Multifaceted Effort

Unlike in animals, the “fight or flight” response isn’t an option for imperiled plants—including those grown as crops for our food, fuel, and fiber needs. A plant, for example, cannot simply uproot itself and sprint to safety from an approaching caterpillar.

But plants can defend themselves, and they’ve done so for millennia, by using an abundance of potent secondary compounds broadly referred to as “phytochemicals.” Some, like glyceollins in soybeans, are produced only in response to a specific threat—similar to the adrenaline surge a person experiences from a life-threatening event. For plants, this threat can be from a grazing animal, the first few chomps of a hungry insect, or the germination of a fungal spore. Other phytochemicals are “constitutive,” meaning they occur continuously to protect vital plant parts. An example is capsaicin, which occurs in chili pepper seeds and gives the fruit its tongue-torching “heat.”

Both phytochemical types have been the focus of scientific attention and formal study for well over 100 years. Agricultural Research Service scientists have been on the forefront of such studies and today conduct projects investigating the defensive responses of plants at laboratories in Peoria, Illinois; Gainesville, Florida; Oxford, Mississippi; Prosser, Washington; and other locations. All of these projects ask the question, “If plants can make their own natural chemical defenses, why the need for synthetic pesticides?”

In part, the answer has to do with the thousands of years of agriculture that preceded our modern-day understanding of plant genetics and advanced breeding technologies. The result of this nascent period was the loss of many plant-beneficial traits in favor of a few desirable ones singled out by humans. In some cases, where phytochemicals imparted a bitter or

undesirable taste (such as alkaloids, a group of compounds believed to function mostly as plant protectants), selecting for plants with lower levels of those phytochemicals may have been deliberate. In either case, the result was a greater need for human intervention in protecting the plants from pests that they once may have been able to defend against on their own.

Here’s another consideration: Even if a crop retained its natural protectants through these early breeding practices, cultivating plants with a limited genetic diversity under unnaturally high densities would have likely resulted in pest pressures reaching levels requiring human intervention.

Additionally, insects and pathogens are notoriously adaptable and can evolve biotypes possessing resistance to the pesticides used against them. The emergence of resistant biotypes can also imperil plants, such that a particular natural defense becomes ineffective. This, in turn, necessitates the development of new strategies, including new pesticides with novel modes of action and the selection for plant traits that defeat or minimize the impact of the pest.

Another approach is to study the genes, biosynthetic pathways, structure, and function of phytochemicals for new clues to shoring up the defenses of today’s crops. This may involve activating long-dormant genes or getting them to activate more quickly and to a greater degree. Engineering new biosynthesis pathways may help plants express phytochemical defenses where and when they’re needed most—and not just against insects or pathogens, but also weeds. For example, ARS researchers in Gainesville have identified 10 compounds in corn that help the plant fend off fungal infection and insect feeding. (Story begins on page 4.)

In addition to the potential environmental benefits of using what plants already have to offer, there are nutraceutical and pharmaceutical gains to be realized: Some of the same phytochemicals that plants use to protect themselves or cope with stress can also benefit humans and livestock animals when consumed. ARS researchers in Peoria, Illinois, for instance, are investigating saponins from soybeans that not only deterred caterpillar feeding in trials, but also diminished growth of cancerous human colon cells in test-tube experiments. Resveratrol, an antifungal agent in grapes, blueberries, cranberries, and other plants, is another subject of biomedical interest, and the field of ethnobotany examines the medicinal, religious, cultural, and other uses of plants by people.

Whether it be for human health benefits or crop protection, we still need to learn more about the regulation and interaction of genes involved in the production of phytochemicals—and what the cost is to the plant if they’re manipulated for elevated expression levels.

More than 100 years of scientific study may have passed, but much has yet to be learned about the fascinating phytochemical story of plants. Then, as now, ARS researchers will continue to “read between the lines,” ferreting out the meaning and practical implications for improved crop productivity, as well as human and environmental health.

Kay W. Simmons

ARS Deputy Administrator
Crop Production and Protection
Beltsville, Maryland

Jack Okamuro

ARS National Program Leader
General Biological Sciences
Beltsville, Maryland

Agricultural Research is published 10 times a year by the Agricultural Research Service, U.S. Department of Agriculture (USDA). The Secretary of Agriculture has determined that this periodical is necessary in the transaction of public business required by law.

Tom Vilsack, Secretary
U.S. Department of Agriculture

Catherine E. Woteki, Under Secretary
Research, Education, and Economics

Edward B. Knipling, Administrator
Agricultural Research Service

Sandy Miller Hays, Director
Information Staff

Editor: Robert Sowers (301) 504-1651
Associate Editor: Sue Kendall (301) 504-1623
Art Director: BA Allen (301) 504-1669
Photo Editor: Anita Daniels (301) 504-1609
Staff Photographers:
Peggy Greb (301) 504-1620
Stephen Ausmus (301) 504-1607

Most information in this magazine is public property and may be reprinted without permission (except where copyright is noted). Non-copyrighted articles and high-resolution digital photos are available at ars.usda.gov/ar.

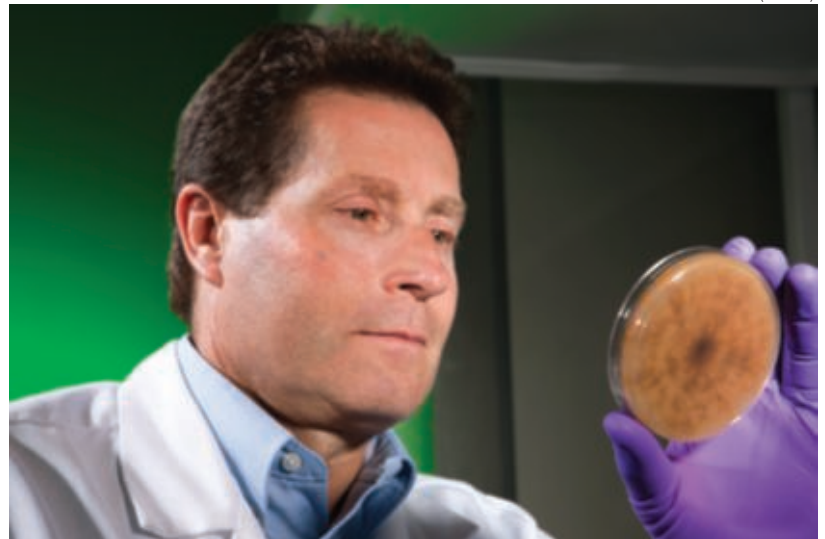
Paid subscriptions are available from the U.S. Government Printing Office (Superintendent of Documents). See back cover for ordering information. Complimentary 1-year subscriptions are available directly from ARS to public libraries, schools, USDA employees, and the news media. Call (301) 504-1638 or e-mail armag@ars.usda.gov.

This magazine may report research involving pesticides. It does not contain recommendations for their use, nor does it imply that uses discussed herein have been registered. All uses of pesticides must be registered by appropriate state and/or federal agencies before they can be recommended.

Reference to any commercial product or service is made with the understanding that no discrimination is intended and no endorsement by USDA is implied.

The USDA prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

PEGGY GREB (D2365-1)



Plant pathologist Carl Strausbaugh evaluates a fungal culture of *Rhizoctonia solani*. Story begins on page 18.

4 Corn Defenses Probed for New Pest-Fighting Clues

7 Comparing Light-Conversion Efficiency of Plants and Manmade Solar Cells

8 Building Baby's Tiny Bones: Formulas and Mother's Milk Analyzed in Animal Study

10 Recognizing the Threat of Leptospirosis

12 Using Cactus as a Bioremediation Tool

14 ARS Scientists Rally 'Round the Range

17 There's a New Biofuel Crop in Town

18 A Search for the Sweet Spot in Sugar Beet Production

20 Nutrient Data in Time for the New Year

22 A Rough, Tough Forage for Rangeland Cattle

23 Locations Featured in This Magazine Issue



Cover: ARS plant/soil scientist Gary Bañuelos and horticulturist Gabriella Romano survey fruit on prickly pear cacti, *Opuntia ficus-indica*, at the ARS San Joaquin Valley Agricultural Sciences Center in Parlier, California. Story begins on page 12. Photo by Stephen Ausmus. (D2351-16)



Corn Defenses Probed for New Pest-Fighting Clues

At the ARS Chemistry Research Unit in Gainesville, Florida, post-doctoral chemist Fatma Kaplan (left) and plant physiologist Eric Schmelz review NMR data and discuss molecular assignments of the new phytoalexin termed “zealexin B1.” Kaplan played a critical role in the NMR analysis and structural clarification of the new defenses.

A clearer picture of corn’s biochemical responses to insect and fungal attacks is emerging, thanks to new findings by Agricultural Research Service scientists in Gainesville, Florida.

On one front, a team led by ARS plant physiologists Eric Schmelz and Alisa Huffaker has identified 10 compounds in corn, kauralexins and zealexins, which rapidly accumulate at fungal infection sites, impeding the microbes’ spread. Kauralexins and zealexins, members of a larger family of plant-defense compounds known as “terpenoid phytoalexins,” are also partly triggered by insect chewing—with *Ostrinia nubilalis*, the European corn borer,

among species that find them distasteful.

On another front, Huffaker led the discovery of a new peptide (protein) in corn, *ZmPep1*, that’s produced in response to fungal infection. In addition to serving as a sort of “call to arms,” the peptide helps the plant mount a timely counter-offense.

“This is the first time a peptide signal has been shown to turn on biochemical defenses in maize,” notes Schmelz, who along with Huffaker published a paper on *ZmPep1* in the March 2011 issue of *Plant Physiology*.

Huffaker, Schmelz, and seven coauthors from ARS and the University of Florida (UF) reported their kauralexin and zealexin findings in the March 2011 issue

of *Proceedings of the National Academy of Sciences* and the August 2011 issue of *Plant Physiology*.

Taken together, the discoveries add significantly to the existing body of knowledge on corn’s stress-coping mechanisms and set the stage for novel approaches to improving its insect and disease resistance.

Entomologist Xinzhi Ni, who collaborated with the teams led by Huffaker and Schmelz, is optimistic that new indices derived from the terpenoid phytoalexin studies will prove useful to a corn-breeding program under way at ARS’s Crop Genetics and Breeding Research Unit in Tifton, Georgia. “We are going to examine the roles of these compounds in

developing insect- and disease-resistant corn germplasm,” says Ni. “This collaborative research is a good example of the synergy between basic and applied research,” he adds.

Zealexins and kauralexins are non-volatile, yet both are derived from volatile organic compound precursors, namely sesquiterpenes and diterpenes, which have been widely studied in plants, including such crops as cotton, beans, and rice. Many scientists have focused on the production and function of terpene volatiles in response to insect leaf-feeding—“not what happens when an insect bores into the stem of a corn plant,” says Schmelz.

Analyses of these previously unknown defense mechanisms were significantly aided by the efforts of ARS postdoctoral researchers Nicole Dafoe and Martha Vaughan, who are in the Chemistry Research Unit at ARS’s Center for Medical, Agricultural, and Veterinary Entomology in Gainesville.

Borer Bullies

By examining the stalk’s genetic and biochemical responses to borer feeding, the team hopes to find clues that will help explain the insect’s success as a top pest of corn—both in the United States and abroad.

After hatching from egg masses deposited by adult female moths, borer larvae spend part of their lives feeding inside stalks—protected from predators or chemical pesticides that farmers might apply to control them. The pest’s feeding and tunneling, in turn, create a humid, frass-filled environment in the stalk that’s conducive to fungal growth. *Colletotrichum graminicola*, which causes anthracnose stalk rot, is among fungal beneficiaries of such feeding—a double-whammy of damage that costs the U.S. corn industry an estimated \$1 billion annually in losses.

About 3 years ago, the teams led by Schmelz and Huffaker, in collaboration with Ni in Tifton, began a project to examine whether corn stalks were capable of churning out terpenoids similar to those produced in leaves when attacked by insects or fungi.

These chambers are used to control humidity levels to mimic infectious conditions and collect volatile organic compounds emitted by corn plants in response to fungal or insect attack.

Using a metabolite profiling method they devised, the researchers were able to detect telltale signs of biochemical activity in response to both stem-borer and fungal attack. Initially, “we didn’t know what the compounds were—only that new analytes on the gas chromatograph kept appearing as sharp peaks when European corn borers fed on the stalks,” recalls Schmelz.

High-Tech Teamwork

The team hit pay dirt, so to speak, upon initiating a nuclear magnetic resonance imaging project with chemist Hans Alborn

Maize faces pressure from insects and pathogens in the field. ARS researchers are investigating the protective role of maize phytoalexins against both types of attacking organisms. Here, a corn earworm feeds on a corn cob infected with corn smut (blue kernels).



ERIC SCHMELZ (028300-1)

and postdoctoral researcher Fatma Kaplan—both in the ARS Chemistry Research Unit—and James Rocca, a chemist at UF’s McKnight Brain Institute in Gainesville. Through this collaboration, the team successfully identified the large number of novel mystery compounds as *ent*-kaurane-related diterpenoids, termed “kauralexins,” and modified C15 carboxylic acids of *b*-macrocarpene, termed “zealexins.”

The researchers learned through later feeding trials that borer larvae can actually stomach the kauralexins without suffering ill effects—they neither die from ingesting the compounds nor grow more slowly. Given the choice, though, the pests avoid feeding on tissues where high levels of kauralexins are present, apparently disliking their taste.

Fungi, however, had a tougher time with the kauralexins and zealexins.

Scientists infected young corn plants with the fungal pathogens *C. graminicola*, *Aspergillus flavus*, and *Fusarium graminearum* and compared the resulting phytoalexin production levels to those in plants that had been mechanically wounded. Both zealexin and kauralexin levels were highest in *F. graminearum*-challenged plants and lowest in those that had been mechanically wounded. This suggests that production of the compounds wasn’t a generalized response to stress but rather a localized reaction to a specific threat—fungi, in this case.

In other experiments, physiologically relevant amounts of kauralexins inhibited



ERIC SCHMELZ (02387-1)



In the greenhouse at the ARS Chemistry Research Unit in Gainesville, plant molecular biologist Alisa Huffaker (left) and postdoctoral research associate Martha Vaughan treat plants with the maize peptide *ZmPep1*, which is a signal to activate a broad array of defenses.

likewise significantly improved the plant's resistance to *Cochliobolus heterostrophus*, which causes southern leaf blight.

In the long term, information gleaned from studies of *ZmPep1* or related peptides opens the door to manipulating their associated genes for improved resistance to diseases affecting not only corn, but also other crops, the researchers note in their *Plant Physiology* paper.

Phytoalexins, such as zealexins and kauralexins, are sure to be part of that story. But they may also be useful in helping explain why corn fares so poorly against the European corn borer. "I think these new terpenoids, as markers, are going to be really good tools to understanding the dynamics of the relationship between the corn plant and this insect," says Schmelz.—
By **Jan Suszkiw, ARS.**

This research is part of Crop Protection and Quarantine (#304) and Plant Genetic Resources, Genomics, and Genetic Improvement (#301), two ARS national programs described at www.nps.ars.usda.gov.

*Eric Schmelz and Alisa Huffaker are in the USDA-ARS Chemistry Research Unit, Center for Medical, Agricultural, and Veterinary Entomology, 1600-1700 S.W. 23rd Dr., Gainesville, FL 32608; (352) 374-5858 [Schmelz], (352) 374-5765 [Huffaker], eric.schmelz@ars.usda.gov, alisa.huffaker@ars.usda.gov.**

growth of *C. graminicola* by 90 percent. Similarly, zealexins inhibited growth of *A. flavus* by 80 percent. *A. flavus* is the causal agent of aflatoxin accumulation in maize and results in significant losses in the United States due to toxin contamination.

Schmelz notes that *C. graminicola* in nature may induce lower levels of the compounds because it is better at masking its presence from the corn plant than less-stealthy pathogens, such as *F. graminearum*.

Generally, these terpenoid defenses appeared within 24 hours of infection, but did not reach peak levels in inoculated stalk tissue until at least 48 hours later.

Cross-sections of a corn stem infected (left) and not infected (right) with *Fusarium graminearum*. ARS scientists have worked to characterize plant defenses induced by *Fusarium* infection.



ERIC SCHMELZ (D2388-1)

Schmelz and Huffaker present compelling evidence that many antimicrobial proteins and other defensive molecules complement the plant's zealexin and kauralexin responses to an attack.

Signals Set the Stage

In related work led by Huffaker, the peptide *ZmPep1* proved to be the key to unlocking an array of antifungal-defense genes. In collaboration with Schmelz, her team's studies indicate the peptide is produced in response to infection by fungal pathogens and activates production of the hormones ethylene and jasmonic acid, which up-regulate small molecule and protein defenses in a timely and effective fashion.

In experiments, corn plants pretreated with *ZmPep1* and then inoculated with *C. graminicola* spores sustained 25-50 percent fewer lesions than non-treated plants. This treatment

Plant physiologist Eric Schmelz and postdoctoral molecular biologist Nicole Dafoe use a gas chromatograph/mass spectrometer to profile the newly discovered kauralexin and zealexin classes of corn phytoalexins.



HANS ALBORN (D2384-1)

When it comes to using light energy, how do manmade photo cells compare to plants' photosynthesis? An Agricultural Research Service scientist participated in a study comparing how efficiently plants and photovoltaic cells convert sunlight into energy. The study, published in *Science*, could help researchers improve plant photosynthesis—a critical first link in the global supply chain for food, feed, fiber, and bioenergy production.

Comparing the two systems is a challenge. Although both processes harvest energy from sunlight, they use that energy in different ways. Plants convert the sun's energy into chemical energy, whereas solar cells produce electricity.

Scientists know that plants are not as efficient as manmade solar cells at converting light into energy, according to research leader Donald Ort in the ARS Global Change and Photosynthesis Research Unit in Urbana, Illinois. "But now we have a way of comparing the two systems more accurately," he said. The study identified specific redesigns that hold excellent promise for improving efficiency.

To facilitate direct comparison between photosynthetic and solar cell systems, the researchers set a uniform basis for the comparison and examined the major factors that define the efficiencies of both processes—first considering current technology, then looking forward to possible strategies for improvements. In all cases, the research team considered the efficiency of harvesting the entire solar spectrum as a basis for comparison. Additionally, the researchers compared plants to solar cell arrays that also

store energy in chemical bonds. Calculations were applied to a solar cell array that was coupled to an electrolyzer that used electricity from the array to split water into hydrogen and oxygen. The free energy needed to split water is essentially the same as that needed for photosynthesis or a solar cell, so the comparison is on a level playing field.

Using this type of calculation, the annual averaged efficiency of solar cell-driven electrolysis is about 10 percent. Solar energy conversion efficiencies for crop plants are about 1 percent, which illustrates the significant potential to improve the efficiency of the natural system.

"While, in the context of our efficiency analysis, solar cells have a clear advantage compared to photosynthesis, there is a need to apply both in the service of sustainable energy conversion for the future," says Ort. "Our ultimate goal is to design food and

biofuel crops that use sunlight energy more efficiently and are thus higher yielding. This energy-efficiency analysis between plant photosynthesis and solar cells will lay the groundwork for improving the efficiency of plant photosynthesis in agriculture for improved yield."

In addition to ARS, numerous other organizations and universities, both in the United States and abroad, participated in various aspects of this research.—By **Sharon Durham, 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.

*Donald Ort is in the USDA-ARS Global Change and Photosynthesis Research Unit, 1206 West Gregory Dr., 1500 IGB, Urbana, IL 61801; (217) 333-2093, don.ort@ars.usda.gov.**



In studies at Urbana, Illinois, ARS scientists (left to right) Carl Bernacchi, Don Ort, and Lisa Ainsworth work in a facility where photosynthesis efficiency and yield can be measured in response to a simulated variable. Improving photosynthesis could lead to increased food production from soybeans, shown here.

Inset: Research leader Don Ort inspects a switch for a device that allows him to adjust a variable in the soybean field.

Photos courtesy of Institute for Genomic Biology/University of Illinois.



Comparing Light-Conversion Efficiency of Plants and Manmade Solar Cells

Building Baby's Tiny Bones

Formulas and Mother's Milk Analyzed in Animal Study

For millions of American infants, a bottle of warm, soy-based baby formula is what's for dinner. It's also what's for breakfast, lunch, and all those between-meal feedings, as well.

At least, that's the routine for a healthy, soy-fed baby's first few months of life. After that, baby may be ready to handle solid food—puréed fruits and vegetables, for instance.

At the USDA-ARS Arkansas Children's Nutrition Center in Little Rock, principal investigator Jin-Ran Chen, M.D., is taking a close look at the effects that soy formula, cow's-milk formula, and mother's milk have in regard to development of strong, healthy bones. As lead scientist in the center's Skeletal Development Laboratory—and a father of two—Chen has a keen interest in this often-debated subject. “Very little is known about the short- and long-term effects of soy formula on bone health,” Chen points out.

In a series of studies, conducted with co-researchers at Little Rock, Chen is helping



PEGGY GREB (D2378-1)

Research associate Oxana P. Lazarenko uses quantitative real-time PCR to find differences in bone-formation gene expression in response to various infant formulas.

to fill in the knowledge gap. One study, for example, has provided a comprehensive comparison of bone formation in piglets that were fed either soy or cow's-milk formula or sow's milk. “No animal model is perfect,” says Chen, “but we chose pigs as the animal model for this research because the pig digestive system is generally regarded as being closest to ours.”

Many Bone-Development Indicators Scrutinized

For this extensive experiment, Chen and colleagues used a range of leading-edge technologies, such as peripheral quantitative CT (computed tomography) scans, which take actual measurements of bone interior and exterior, and real-time reverse transcription polymerase chain reaction assays (real-time RT-PCR), which enable the scientists to analyze expression (turning on) of genes that play a pivotal role in bone formation. The study encompassed more than a half-dozen well-established indicators of bone quality and quantity (mass), making the investigation one of the most detailed of its kind.

In follow-up studies of the relation of infant formula to baby's bone health, principal investigator Jin-Ran Chen, at the Arkansas Children's Nutrition Center, is using Illumina analysis to investigate changes in genes.



PEGGY GREB (D2377-1)

In general, the work “suggests that soy-formula-fed piglets may have the best quality bone,” says Chen. The research also suggests that soy may enhance bone formation by directly affecting the BMP2 (short for “bone morphogenesis protein”) signaling pathway.

Signaling, or messaging, initiated by BMP2 and targeted to other bone-forming molecules along the BMP2 signaling pathway “is absolutely essential for building and reforming bone,” Chen says. Though scientists have known of the existence of a BMP2 signaling pathway for several decades, details are still being uncovered. Chen’s study was the first to spotlight soy’s relative influence on initiating BMP2 signaling.

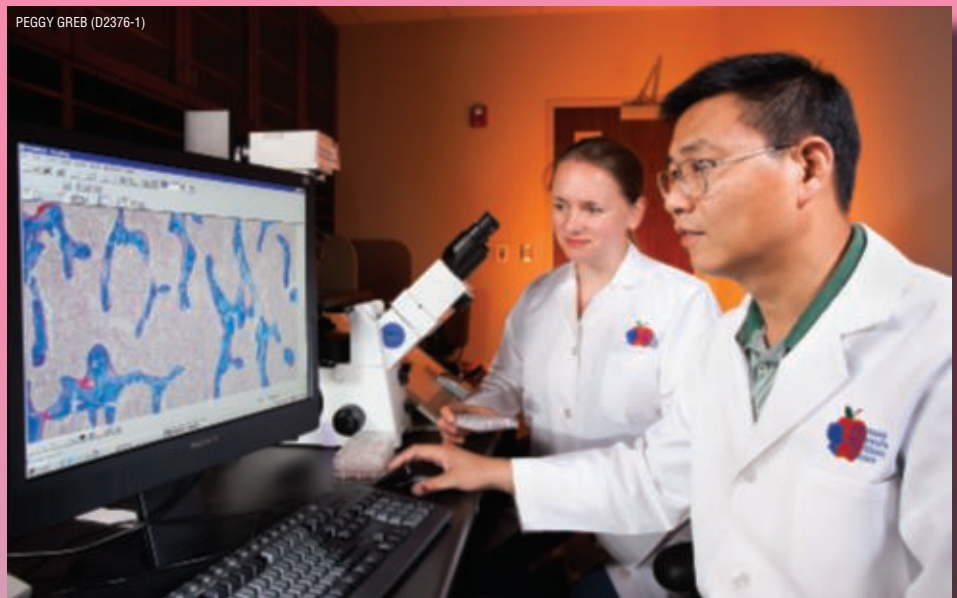
Other findings from the study similarly underscore soy’s possible advantages. For example, soy-fed animals:

- had greater bone mineral density and bone mineral content, two key indicators of bone strength, at 21 or 35 days after birth.
- formed bone at a faster rate.
- had a greater number of osteoblasts, specialized cells that become functioning bone cells.
- had a lower number of osteoclasts, cells that, in a process known as “resorption,” break down bone so that calcium and other bone minerals can be used elsewhere in the body.

SCOTT BAUER (K-9455-1)



For the bone-health research, piglets were fed soy or cow’s-milk formula or sow’s milk.



Lazarenko and Chen discuss piglet bone and tissue changes after feeding the animals different infant formulas or sow’s milk.

Chen collaborated in the work with Thomas M. Badger, center director, and Martin J.J. Ronis, a principal investigator there. All three are also members of the research faculty at the University of Arkansas for Medical Sciences in Little Rock. Also collaborating were center research associates Jamie V. Badeaux, Michael L. Blackburn, and Oxana P. Lazarenko. Their findings are documented in a 2009 article in the *Journal of Nutrition*.

Chen’s ongoing animal-model studies provide a longer term look at soy’s effects in comparison to the other feeding options. A collaboration with researcher Aline Andres may help determine whether effects noted in the animal studies hold true for human infants. Rechecks of the young participants’ bone health at later intervals in their lifetimes would be invaluable. “We want to learn more about the extent to which early nutrition influences bone health later in life,” explains Chen. “We’re especially interested in determining the impact that early nutrition can have in preventing or delaying onset of age-related degenerative bone diseases, particularly osteoporosis.”

“Breastfeeding is recommended by the American Academy of Pediatrics,” says Badger. “Milk-based formula is the second choice, and soy formula is third. Although 62 percent of U.S. infants were breastfed as newborns in 2008, 73 percent of those transitioned to infant formula between birth and age 6 months. In all, it’s estimated that about 20 percent of formula-fed infants are fed soy protein-based formula during their first year of life. Identifying the potential benefits or adverse effects of these early nutrition choices is important. We need a better understanding of their impact on growth, development, nutritional status, promotion of health, and prevention of disease. We believe the findings from our studies are improving our understanding of early nutrition and will help pediatricians, parents, other researchers, and policymakers make informed choices.”—By **Marcia Wood, ARS**.

This research supports the USDA priority of improving children’s nutrition and health and is part of Human Nutrition, an ARS national program (#107) described at www.nps.ars.usda.gov.

*Jin-Ran Chen and Aline Andres are with the USDA-ARS Arkansas Children’s Nutrition Center, 15 Children’s Way, Little Rock, AR 72202; (501) 364-2707 [Chen], (501) 364-3301 [Andres], chenjinran@uams.edu, andresaline@uams.edu.**

Recognizing the Threat of Leptospirosis

Cattle, hamsters, and sea lions may seem like an odd combination, but they do have something in common—leptospirosis, a contagious disease found in all farm animals, rodents, and wildlife.

Leptospirosis, which is caused by *Leptospira* bacteria, is a widespread zoonotic disease transmitted naturally from domestic and wild animals to humans, who can become infected through contact with water, food, or soil contaminated with urine from infected animals.



Technician Rick Hornsby of the Infectious Bacterial Diseases Research Unit examines culture medium for cloudiness, which indicates growth of *Leptospira* bacteria.

“The disease in humans can often be an acute infection,” says lead scientist Richard Zuerner, a former microbiologist with the Agricultural Research Service’s National Animal Disease Center (NADC) in Ames, Iowa. “In areas where it is endemic, like Brazil, it occurs on a periodic basis, and a portion of those infected will experience pulmonary hemorrhage, which can lead to a very rapid and painful death.”

Leptospirosis in livestock can cause abortions, stillbirths, reduced milk production, and lower fertility, Zuerner says. In horses, it can also result in uveitis, a potential cause of blindness.

Less is known about leptospirosis in wildlife, such as California sea lions, but scientists are finding out how the disease is spread in these mammals, exploring vaccines for cattle that carry the virus,



THE MARINE MAMMAL CENTER (D2394-1)

and using hamsters as models to better understand leptospirosis.

Sizing Up the Risk of Leptospirosis from Sea Lions

Instinct may tell people to run to the aid of helpless sea lions stranded along the West Coast, but logic will tell them to be cautious. California sea lions infected with leptospirosis pose a potential threat to public health.

Senior scientist Frances Gulland examines sick and dying seals and sea lions at the Marine Mammal Center in Sausalito, California, where she works. When a leptospirosis epidemic in sea lions occurred in 2004, Gulland and her team collected urine and kidney samples and sent them to NADC for evaluation.

There, Zuerner and David Alt, a veterinary medical officer in NADC’s Infectious Bacterial Diseases Research Unit, identified the strain—*L. interrogans* serovar Pomona—that causes infection in sea lions. Pomona also affects cattle and other species.

Scientists with ARS and the Marine Mammal Center in Sausalito, California, are studying leptospirosis in California sea lions to learn more about the disease and its spread in this marine mammal and in other animals, such as cattle.

Sea lions periodically undergo acute infection outbreaks. However, research suggests that California sea lions are becoming maintenance hosts.

“Maintenance hosts normally carry the bacteria and show few outward signs of infection,” Zuerner says, “whereas accidental hosts, like humans, often come down with a severe infection.”

With the help of marine and wildlife agencies, scientists maintain a surveillance network along the Pacific coast to locate sick marine mammals. They have found that the spread of leptospirosis coincides with northern seasonal migration of males from breeding areas along the southern California coast.

“The first cases of disease outbreak were in southern California, and by the end of the year, disease-infected sea lions were found in Canada and Washington,” Zuerner says.

In 2011, sick and dying sea lions washing up from central California to the Oregon coast showed signs of kidney failure, which can be caused by leptospirosis, Gulland says. Tests revealed that some of the sea lions were infected with the disease.

How did *Leptospira* get into sea lion populations? This question has puzzled scientists since the disease was discovered in California sea lions in the 1970s.

“We really don’t know,” Gulland says. “We hope to find the possible source by cross-matching the strain that affects sea lions with strains from other mammals.”

A Vaccine that Induces Immunity

For cattle producers, the question may be how effective is a vaccine at reducing the shedding—excretion of bacteria by the host—and spreading of leptospirosis in their herds. To answer this question, NADC scientists continue to develop and evaluate vaccines for potency.

Several years ago, they tested a vaccine and found that it induced some protection against experimental infection with *L. borgpetersenii* serovar Hardjo, the primary cause of bovine leptospirosis worldwide.

Recently, Zuerner, Alt, and their colleagues at NADC—veterinary medical officers Mitchell Palmer and Steve Olsen and microbiologist Tyler Thacker—examined the commercial version of the vaccine for its ability to provide short-term and long-term protection against experimental serovar Hardjo infection.

Cattle were vaccinated twice with the commercial vaccine, a standard vaccine, or an adjuvant only (a control vaccine). One year after the second vaccination, animals were challenged with serovar Hardjo.

Another part of the study tested the commercial vaccine’s ability to induce short-term immunity to infection. Animals were immunized twice and challenged 3 months later.

The commercial vaccine appeared to be effective, Alt says. It induced greater immunologic responses than the standard vaccine and greater protection against shedding after challenge. However, it did not provide complete protection from shedding.

“One of the big differences between the 3-month versus the 1-year vaccination with the commercial vaccine is that we couldn’t detect any bacteria in either the urine or the kidney at the end of the short-term study,” Zuerner says. “Animals vaccinated and then challenged with the live bacteria were able to clear the bacterial infection of the kidney more efficiently.”

In the yearlong study, only one animal was shown to have bacteria in the kidney, he says.

The immune system of vaccinated animals exhibits a recall response and naturally elicits an appropriate reaction against the bacteria.

“The vaccine triggered immunological memory in NK cells—or natural killer cells—a group of white blood cells that, like gamma delta T cells, are a bridge between the innate and acquired immune system,” Zuerner says. “Results indicate that both NK cells and gamma delta T cells may have a role in limiting or clearing infection.”

Leptospira is a varied group of organisms containing more than 200 serovars that can cause leptospirosis, Alt says. The difficulty is that there’s almost no visible difference within the genus.

“Getting the right vaccine depends on the infecting serovar,” he says. “That’s why it’s important to continue work, despite seeing improvements with the vaccine we evaluated.”

Hamsters Are Effective Models for Leptospirosis

For some time, scientists have relied on a widely used hamster model to study the effects of leptospirosis and evaluate vaccines. But attempts to demonstrate lethal infection with Hardjo in hamsters were sporadic at best.

“The previous experiments were done before we knew serovar Hardjo occurred in two species,” Zuerner says. “So it wasn’t clear beforehand whether *L. interrogans* serovar Hardjo or *L. borgpetersenii* serovar Hardjo was being tested.”

“In the prior studies, there was no way to differentiate clearly or genetically which particular Hardjo was used to induce a lethal infection in hamsters,” Alt says.

In a recent study, NADC scientists paired two closely related *L. borgpetersenii* serovar Hardjo isolates. One strain produced an acute, potentially lethal infection, and the other strain produced a long-term chronic infection.

Hamsters challenged with the chronic strain at first appeared unaffected. But at the end of the study, large numbers of bacteria were observed in the kidney.

“We’re now looking at using the hamster model to understand aspects of leptospirosis and trying to identify the differences between the disease induced by the hamster-lethal strain versus the chronic strain,” Zuerner says. “The strain that develops a chronic infection more closely mimics the type of infection we see in cattle.”

These findings should prove useful for evaluating leptospirosis vaccines in small animals, Zuerner says. Small-animal studies can be conducted easily in labs and lead to vaccines that may also work for large animals.—By **Sandra Avant, ARS**.

This research is part of Animal Health, an ARS national program (#103) 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.**

Technician Ami Frank studies images of *Leptospira* in silver-stained experimental tissues while veterinary medical officer David Alt observes.



PEGGY GREB (D2391-1)

Using Cactus as a I



STEPHEN AUSMUS (D2356-4)

Newly emerging cladode with flower on field-grown prickly pear cactus, *Opuntia ficus-indica*.

The west side of the San Joaquin Valley in California presents several challenges to growers. Ancient seas that once covered the area left behind marine sediments, shale formations, and deposits of selenium and other minerals. Anything grown there needs to be irrigated, but the resulting runoff, when it contains high levels of selenium, can be toxic to fish, migratory birds, and other wildlife that drink from waterways and drainage ditches. Selenium runoff is subject to monitoring by regional water-quality officials. Periodic droughts and population growth are also



GARY BAÑUELOS (D2405-1)

squeezing supplies of the fresh water available for irrigation.

“We need to find a way to keep the land productive, but that becomes difficult when you have environmental concerns stemming from soils with these mineral deposits,” says Gary Bañuelos, an Agricultural Research Service plant/soil scientist with the Water Management Research Unit at the San Joaquin Valley Agricultural Sciences Center in Parlier.

Bañuelos believes that he has found a promising alternative: prickly pear cactus (*Opuntia ficus-indica*), a drought-tolerant plant. Bañuelos’s studies show that certain cacti tolerate salty soil and take up selenium from it. “We’re hoping to produce a new crop on unproductive land and slowly manage the selenium content of the soil in the process of growing it,” Bañuelos says.

Bañuelos and his colleagues from the University of Palermo, Italy, initially evaluated varieties of *O. ficus-indica* from the USDA-ARS National Arid Land Genetic Resources Unit at Parlier, which maintains and evaluates plant germplasm adapted to arid conditions. The team’s evaluation focused on the ability of different varieties to tolerate poor-quality soils in greenhouses. Partners in Palermo included Viviana Catanese and Giuseppe Alonzo.

Prickly pear cactus fruit.



STEPHEN AUSMUS (D2354-7)

Above: Typical salty and selenium-laden soil planted to cotton in the west side of central California.

Right: ARS plant/soil scientist Gary Bañuelos (right) and grower John Diener survey prickly pear cactus growing well in poor-quality soil.

After making those observations, Bañuelos then spent 3 years evaluating five prickly pear varieties from Mexico, Brazil, and Chile for salt and boron tolerance in selenium-laden soils by collecting soils and sedi-



STEPHEN AUSMUS (D2352-4)

Bioremediation Tool



STEPHEN AUSMUS (D2355-11)

ments from the area and growing the varieties in field test plots at the research center in Parlier. He followed normal agronomic practices for the area and used a drip irrigation system that pro-

At the USDA-ARS San Joaquin Valley Agricultural Sciences Center in Parlier, California, technician Irvin Arroyo cuts a cladode from a prickly pear cactus.



duced very little runoff. Results, published in *Soil Use and Management*, showed the prickly pear grew reasonably well in the poor quality soil with very little water. Unexpectedly, the plants also took up selenium, volatilizing some of it and keeping some in their fruit and leaf-like stems (cladodes). Other nonessential minerals were not found in higher concentrations in these plant parts.

Prickly pear was thought to be sensitive to high salinity. But the study results showed that tolerance to salt and boron depends on the genotype. The cactus variety from Chile had the highest tolerance and was the best at producing fruit and accumulating and volatilizing selenium. Many of the plants grown in test plots were smaller and produced less fruit than those in control plots, but some varieties actually grew better in the test plots. The results were promising enough for selected prickly pear



GARY BAÑUELOS (D2406-1)

Prickly pear cactus fruit.

varieties to be considered as a gentle bioremediation tool for soils loaded with selenium.

“We’ve found this plant needs minimal amounts of water, plus it can survive in these saline and boron soils laced with selenium,” Bañuelos says.—By **Dennis O’Brien, ARS.**

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

*Gary Bañuelos is in the Water Management Research Unit, San Joaquin Valley Agricultural Sciences Center, 9611 S. Riverbend Ave., Parlier, CA 93648-9757; (559) 596-2880, gary.banuelos@ars.usda.gov.**



Prickly pear cactus fruit.

GARY BAÑUELOS (D2407-1)

ARS Scientists Rally 'Round the Range

Rangelands in the western United States provide essential grazingland for hundreds of thousands of cattle and other livestock as well as a home for a vast array of native plants and animals. And since these rangelands make up a large part of the U.S. public land system, taxpayers often foot the bill for upkeep of the hardscrabble holdings. So Agricultural Research Service scientists across the West are collaborating to make sure the money used to sustain and repair these arid ecosystems is spent on programs that work.

A Burning Issue

For millennia, periodic wildfires have been an integral part of the rangeland equilibrium among plants, animals, terrain, and climate in the western United States. But changing climatic patterns and invasive plants like cheatgrass now fuel fires that are more frequent—and more fierce—and the previous balance of fire, flora, and fauna has been lost. So after fires, public land managers often quickly reseed burned areas to provide watershed protection and control soil erosion.

“Right now restoration plans must be submitted 3 weeks after a fire has occurred, before plants have had time to recover on their own. We need to figure out how to evaluate the extent of postfire mortality



In fall 2011, at ARS's Northern Great Basin Experimental Range near Burns Oregon, rangeland scientist Tony Svejcar (left), technician Lori Ziegenhagen, and plant physiologist Jeremy James examine the establishment of blue bunch wheatgrass.

for plants and decide whether or not it's always necessary to reseed after fires,” says rangeland scientist Tony Svejcar. He's the research leader at the ARS Range and Meadow Forage Management Research Unit at the Eastern Oregon Agricultural Research Center (EOARC) in Burns, Oregon—right in the heart of high sagebrush country, where the lab equipment includes a working fire truck.

“Lots of land is reseeded, and it's expensive—and when we look at the number of plants that become established after reseeded, the failure rate is really high,” adds Jeremy James, another rangeland scientist at EOARC. “We need to find a way to increase the probabilities of success.”

Although seeds planted in the fall on postfire rangelands usually germinate over winter and spring, their low establishment rates are often attributed to insufficient precipitation or competition from invasive grasses. So James and Svejcar compared the success of post-fire reseeding management on four sites in Oregon where wildfires in 2007 had burned a total of 300,000 acres.

The scientists obtained seeds for an assortment of rangeland species, including desert wheatgrass, western wheatgrass, basin wildrye, Snake River wheatgrass, Sandberg bluegrass, Siberian wheatgrass, yarrow, and blue flax. Then they seeded study plots either with a rangeland drill—the most commonly used method to reseed postfire sites—or by hand, so



In fall 2010, at ARS's Northern Great Basin Experimental Range near Burns Oregon, plant physiologist Jeremy James sets up 1-square-meter plots for planting to determine seedling establishment.

that burial depth could be tightly controlled. In addition, some plots received irrigation and weeding so that the relative importance of seed placement, annual precipitation, and competition from weeds could be assessed.

Seeds vs. Weeds

Before the study started, James thought the most pampered plots—those where seeds were buried by hand at appropriate depths, watered, and weeded—would have the highest rates of establishment. But he was only partially right.

“We had the best seed establishment in hand-seeded plots—around 14 plants per square meter, compared to only around 4 plants per square meter in the drilled plots,” James says. “But weeding or watering didn’t affect the outcome at all.” This indicates that soil water availability in spring was sufficient to support seedling growth and that weed abundance was not high enough to interfere with growth, he says.

James and Svejcar also note that although the wildfires at the four study sites burned away all the sagebrush, other quick-growing native perennial herbs soon recovered, which suggests that some postfire landscapes might not need reseeding at all. In their study, invasive cheatgrass didn’t pose a challenge to the reestablishment of native perennials because it didn’t come back in high densities after the fires. The scientists published their results in 2010 in *Rangeland Ecology & Management*.

Taken together, these findings suggest that it could be time to revamp traditional approaches to postfire rangeland restoration, starting with assessments of whether reseeding is even necessary. If it is, this research suggests that major improvements to restoration success will be linked to advances in seeding technology and improving seed-soil contact. It appears that traditional assumptions about limitations to rangeland restoration—drought and weeds—don’t limit successful seed establishment nearly as much as the seeding practices currently



At ARS’s Northern Great Basin Experimental Range near Burns Oregon, technician Lacy Carpenter evaluates seedling productivity by counting seedlings in the establishment plot.

used by land managers, at least under the conditions studied by James and Svejcar.

“So far, relatively long and cold winters have helped to control cheatgrass in some areas, but those conditions are changing,” says Svejcar. “We need to get better at restoring rangeland with desirable plants that compete with cheatgrass.”

“As a result of this research, we now have a fairly clear indication of the importance seeding technology has in restoration success relative to drought and competition from weeds. It appears that small improvements in seeding technology could yield large increases in rangeland restoration success,” says James.

Southwest Success

Meanwhile, many rangelands in the southwestern United States have been stripped of vegetation by residential development, mining operations, recreational activities, and other changes to the landscape. That reduces habitat for wildlife and forage for grazing, makes the soil susceptible to erosion, reduces water infiltration, and even creates more

dust along highways, reducing visibility for drivers.

Conditions in the arid region make restoring degraded vegetation extremely difficult. Summer temperatures can exceed 100°F for days at a time, and rainfall is scarce and highly variable. The monsoon season in late summer and early fall is the preferred time for planting, but rainfall patterns are unpredictable and the monsoons can arrive anytime between July and September. The cost of irrigating remote, undeveloped range sites is often prohibitive.

Mary Lucero, a molecular biologist at ARS’s Jornada Experimental Range in Las Cruces, New Mexico, is looking for ways to fortify native grasses so that they will be better equipped to restore degraded rangeland habitats. In long-term studies, she is exploring whether microbes associated with hardy woody shrubs can be transferred into native grasses so they can be used as rangeland restoration tools. As part of that effort, she is evaluating the competitive abilities of grasses that have been treated with various microbes and transplanted into the remote desert habitat.



At a remote site in the northern Chihuahuan Desert, ARS molecular biologist Mary Lucero (left) and New Mexico State University graduate student Lori Kae Schwab evaluate establishment and reproductive success of black grama grass, *Bouteloua eriopoda*, transplants. The PVC tubes embedded in the ground contain a hydrogel, which irrigates the transplants.

In a related experiment, Lucero and her colleagues filled tubes fashioned out of PVC pipes with hydrated gels, buried them alongside the roots of a native bunchgrass, and positioned the pipes so that moisture would be available to the grass roots. Lucero designed the experiment to determine whether the hydrogel-filled tubes could provide enough moisture in the dry, remote region to ensure the survival of the native grasses that she is studying.

Hydrogels are already used in some commercial products for jump-starting grass seedlings and for cutting back on how often a gardener has to water a garden. Lucero initially tested both an acrylic crystal gel marketed as “Soil Moist” and a starch-based gel known as “Soil Moist Natural.” But she chose to work exclusively with the acrylic gel because it is easier to manage and less likely to allow moisture to seep too deeply into the soil for the shallow grass roots to reach.

In results published in the *Journal of Arid Environments*, Lucero and her colleagues found that 1 liter of hydrogel-bound water was sufficient to support black grama grass (*Bouteloua eriopoda*) transplants through reproductive maturity. More recently, nearly 700 greenhouse-propagated native plants hydrated with the gels have survived transplanting and become established in field plots in the Chihuahuan Desert environment—and have produced offspring.

Lucero’s results show that hydrogels can be used to irrigate native grasses transplanted into harsh, dry environments

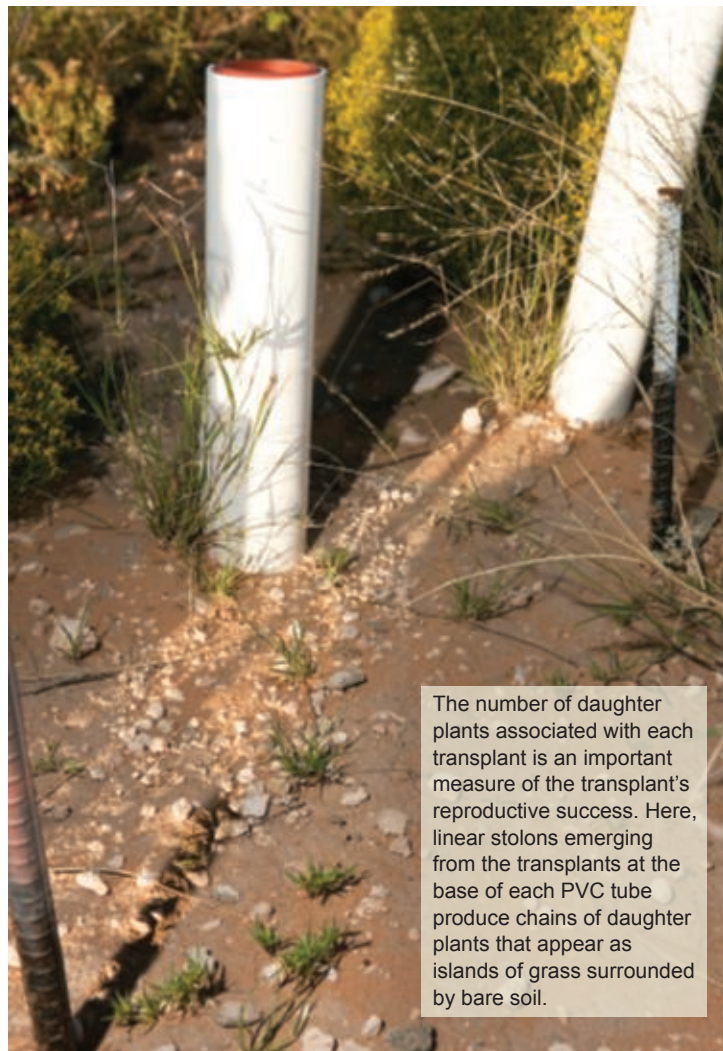
and that they may be useful tools for studying restoration of rangeland habitats.

Back in Burns, Svejcar reflects on the dynamics driving the need for rangeland studies. “Lots of rangeland is still in good shape because a lot of people have put a lot of effort into effective rangeland management,” he says. “Now we need to keep up successful management of the intact rangeland and also focus on restoring the damaged rangelands. And we need to deliver products that help land managers achieve both goals.”—By **Dennis O’Brien** and **Ann Perry, ARS**.

This research is part of Pasture, Forage, and Rangeland Systems (#215), an ARS national program described at www.nps.ars.usda.gov.

Tony Svejcar and Jeremy James are in the USDA-ARS [Range and Meadow Forage Management Research Unit](http://www.ars.usda.gov), 67826-A, Hwy. 205, Burns, OR 97720-9399; (541) 573-8901 [Svejcar], (541) 573-8911 [James], tony.svejcar@ars.usda.gov, jeremy.james@ars.usda.gov.

*Mary Lucero is at the USDA-ARS [Jornada Experimental Range](http://www.ars.usda.gov), 2995 Knox St., Las Cruces, NM 88003; (575) 646-4842, mary.lucero@ars.usda.gov.**



The number of daughter plants associated with each transplant is an important measure of the transplant’s reproductive success. Here, linear stolons emerging from the transplants at the base of each PVC tube produce chains of daughter plants that appear as islands of grass surrounded by bare soil.

There's a New Biofuel Crop in Town

Work by Agricultural Research Service scientists in Florence, South Carolina, suggests that farmers in the Southeast could use the tropical legume sunn hemp (*Crotalaria juncea*) in their crop rotations by harvesting the fast-growing annual for biofuel.

Agricultural engineer Keri Cantrell, agronomist Philip Bauer, and environmental engineer Kyoung Ro all work at the ARS Coastal Plains Soil, Water, and Plant Research Center in Florence. They compared the energy content of sunn hemp with cowpea (*Vigna unguiculata*)—another common regional summer cover crop—in 2004 and 2006.

The crops were grown in experimental plots near Florence, and both were harvested on the same day, three times in each study year. The last harvest in both years was conducted right after the first killing freeze of the season.

The scientists measured potential thermal energy production of both feedstocks via direct combustion. This provided the feedstocks' "higher heating value," which indicates how much energy is released via combustion.

In 2004, when there was ample rainfall, the resulting sunn hemp biomass yield exceeded 4.5 tons per acre. This is equivalent to 82.4 gigajoules of energy per acre—close to the energy contained in 620 gallons of gasoline and well in the ballpark of other bioenergy crops, which have yields of anywhere from 30 to 150 gigajoules per acre.

The higher heating value of sunn hemp biomass exceeded that of switchgrass, Bermuda grass, reed canarygrass, and alfalfa. And although reduced rainfall resulted in lower hemp biomass yields in 2006, sunn hemp's higher heating value for both study years was 4 to 5 percent greater than that of cowpea.

Growing sunn hemp as a cover crop could one day help U.S. farmers meet growing demands for environmentally sustainable biofuel feedstocks. But more research is needed, particularly in regard to managing sunn hemp's content of minerals known to affect biofuel production.—By **Ann Perry, ARS.**

Keri Cantrell, Kyoung Ro, and Philip Bauer are in the USDA-ARS Coastal Plains Soil, Water, and Plant Research Center, 2611 W. Lucas Street, Florence, SC 29501-1242; (843) 669-5203, ext. 113 [Cantrell], ext. 107 [Ro], ext. 137 [Bauer], keri.cantrell@ars.usda.gov, kyoung.ro@ars.usda.gov, phil.bauer@ars.usda.gov.*

A Search for the Sweet Spot in Sugar Beet Production

The whole point of growing sugar beets is to produce sugar.

But once the beets are harvested and stored for processing—usually in huge piles that can weigh thousands of tons—they slowly start to decay, which lowers their sucrose levels.


Roots store sugar even more poorly if they originate from fields infested with the virus that causes rhizomania, a disease that also severely affects yield. Resistance genes in sugar beet help protect the plant from rhizomania, but some strains of the virus have evolved to overcome one of the resistance genes, *Rz1*.

“The economic loss from damage to stored beets is quite large,” says plant pathologist Carl Strausbaugh, who works at the Agricultural Research Service’s Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho. “For instance, if we could figure out how to save even 1 percent of the sucrose in beets during storage, it could save producers in the Pacific Northwest \$4 million every year.”

The Best Beets

For years, Strausbaugh and ARS molecular biologist Imad Eujayl have studied sugar beets from the field—where a strong wind can twist tiny seedlings right out of the ground—to the processing factory. Eujayl also works at the ARS laboratory in Kimberly.

The two researchers have made several key findings about the pathology



Close-up of sugar beet leaf infected with curly top. Symptoms evident here include leaf curling and thickening of the veins and leaf.

PEGGY GREER (D2358-1)

of rhizomania, which is caused by beet necrotic yellow vein virus (BNYVV). Some of their evidence suggests that the right genes can help keep beets from going bad and losing sugar during storage.

The team grew around 30 commercial sugar beet varieties in 2006 and 2007 in fields that were naturally infested with BNYVV. Then they collected samples from each variety—all of which showed some evidence of

typical rhizomania infection—and calculated the average sugar content of each variety after at least 4 months in storage.

The scientists found that roots from some varieties stored indoors had lost as much as 100 percent of their recoverable sugar content, and roots from some varieties stored outdoors had lost as much as 60 percent.

The scientists also observed that the beet varieties that exhibited the greatest rhizomania resistance and the best storability—indicated by the lowest levels of fungal growth and lowest levels of weight loss from root damage—also had the highest sugar levels. Breeders can use this information to develop new varieties that retain more sugar during storage, based on selecting for storability and improved resistance to rhizomania.

Appearances Are Deceiving

Strausbaugh’s studies also established a whole new model that explains how pathogens succeed in infecting healthy sugar beets.

“The fungus *Rhizoctonia solani* was thought to be responsible for most of the root rot we see in Idaho sugar beet, and it does have a certain amount of impact,” Strausbaugh says. “But we found that most root mass is lost to bacterial activity, not fungal activity.”

Along with plant geneticist Anne Gillen, who now works in the ARS Crop Genetics Research Unit in Stoneville, Mississippi, Strausbaugh confirmed that the gram-positive bacterium *Leuconostoc mesenteroides* subsp. *dextranicum* is responsible for around 70 percent of the loss in beet root mass. “We showed that *L. mesenteroides* starts the fermentation process in the root mass, which then creates a pathway for other organisms to come in and cause spoilage,” Strausbaugh says.

This might sound like business as usual between successful microbes, but results from this research—which were published in *Plant Disease* in 2008—helped to confirm that gram-

PEGGY GREB (D2357-1)



Plant pathologist Carl Strausbaugh rates a sugar beet plant for the viral disease known as "curly top."

positive bacteria like *L. mesenteroides* can be the first pathogen—and often the most damaging one—involved in the root rot process.

Curtailing Curly Top

Every year, western U.S. sugar beet producers also battle beet curly top virus, which is transmitted by beet leafhoppers. Back in the lab, Eujayl set out to develop a set of genetic markers that plant breeders could use in developing curly top-resistant sugar beet varieties.

Strausbaugh and Eujayl started by infecting 200 wild, commercial, or other different sugar beet varieties with curly top. Then they ranked each plant according to the severity of its physical responses to infection. When these visible physical responses are the result of the underlying genetics, they are called "phenotypic" traits.

Eujayl then analyzed the phenotypic data with 1,000 sugar beet DNA genetic markers that had been identified by a process called "diversity array technology" (DART). He analyzed these markers to identify which ones were associated with the disease-resistance genes. The analysis indicated that 11 of these genetic markers were significantly associated with resistance to curly top—and that 5 of the 11 markers were linked to the phenotypic resistance trait.

"The DART markers are abundant compared to other marker systems, like simple sequence repeat

markers or single nucleotide polymorphism markers. Using DART allowed us to identify many markers that we would not have found with the other techniques," Eujayl says.

Strausbaugh also conducted a 2-year field study in southern Idaho to see whether curly top damage could be controlled by treating sugar beet seeds with insecticides, which controls the leafhopper that transmits the virus. Working with colleagues, he treated seeds from four sugar beet cultivars with one of two commercial pesticides, Poncho Beta or Gaucho.

The researchers observed that both insecticides reduced the incidence of curly top in the fields. But as the growing season progressed, plants grown from seeds treated with Poncho Beta produced higher yields, especially in hybrids that were more vulnerable to the disease.

Averaged across all tested cultivars, the recoverable sugar content increased 21 percent. Because of that substantial increase in yield, the U.S.

Environmental Protection Agency used these data sets to issue an emergency exemption for the use of Poncho Beta. Since genetic resistance to curly top is not always available, Poncho treatment will allow for near-normal levels of sugar beet production, and it also provides an excellent research tool for breeders to use in evaluating other plant diseases.

"The environmental footprint from using foliar insecticides to protect young sugar beet plants is very large," Strausbaugh says. "However, treating the seed with Poncho leaves a much smaller environmental footprint and can protect young plants through the early season growth stages, when they're highly susceptible to curly top."—By

Ann Perry, ARS.

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.

*Carl Strausbaugh and Imad Eujayl are with the USDA-ARS Northwest Irrigation and Soils Research Laboratory, 3793 North 3600 East, Kimberly, ID 83341; (208) 423-6594 [Strausbaugh], (208) 423-6544 [Eujayl], carl.strausbaugh@ars.usda.gov, imad.eujayl@ars.usda.gov.**

Plant pathologist Carl Strausbaugh (foreground) and technician Joshua Reed mark field plots in a disease-screening nursery in Kimberly, Idaho.

PEGGY GREB (D2360-1)



PEGGY GREB (D2366-1)

Molecular biologist Imad Eujayl scores genetic markers associated with resistance to curly top in sugar beet.



Nutrient Data in Time for the New Year

Black pepper pork chops with molasses butter.

Federal rules published in 2010 require specific meat and poultry products to carry new nutrition information starting January 2, 2012. USDA's Food Safety and Inspection Service (FSIS) announced that the new rules will make important nutrition information readily available to consumers on 40 of the most popular cuts of meat and poultry. Two timely data sets provided by the Agricultural Research Service's Nutrient Data Laboratory (NDL) in Beltsville, Maryland, are being used by the beef and pork industries to provide the new Nutrition Facts labels for their products.

Previously, NDL researchers, in collaboration with representatives of the beef and pork industries and various universities, conducted several studies designed to update and expand the available nutrient data on current beef and pork cuts and products. The results led to a major update of beef and pork nutrient data in the U.S. Department of Agriculture's National Nutrient

Database for Standard Reference Release 24. Called "SR24" for short, the database is the major authoritative source of information about U.S. food composition. The study results have also been incorporated into two downloadable data sets.

SR24 includes more than 7,500 food items and is managed by NDL, which is part of the ARS Beltsville [Maryland] Human Nutrition Research Center. NDL is headed by research leader Joanne Holden.

"Providing new nutrient data for fresh meat products is important, since animal husbandry practices and industry procedures change and improve over time, resulting in changes in nutrient content," says Holden. "The beef and pork industries have been working closely with NDL and will be using the NDL beef and pork nutrient data sets generated through the collaborations for the new meat nutrient-labeling purposes."

Under the new rule, packages of single-ingredient meat cuts, ground meat, and

poultry will have to carry the Nutrition Facts panels. Previously, few ground-meat retailers voluntarily provided their own meat labels.

In addition, nutrition information for single-ingredient cuts—as provided at the butcher case at grocery stores—will be displayed for consumers on a poster near the butcher counter point-of-purchase.

Nutrition Facts labels on foods help consumers follow the recommendations in the "Dietary Guidelines for Americans," which are issued every 5 years by USDA and the Department of Health and Human Services.

"We started working with the National Pork Board on studies that allowed us to update nutrient data on pork in 2005," says Juhi Williams, a nutritionist at NDL specializing in meat and poultry. "We determined new nutrient-composition data,



both raw and cooked, for nine fresh pork cuts—shoulder blade steak, tenderloin roast, top loin chop, top loin roast, sirloin roast, loin chop, rib chop, country style ribs, and spare ribs,” says Williams. “We also studied fresh ground pork at various fat levels.”

NDL chemist Kristine Patterson and nutritionists Seema Bhagwat and Marybeth Duvall also worked on a study sponsored by the National Cattlemen’s Beef Association (NCBA) to determine the nutrient composition of 13 raw and cooked retail beef cuts with fat trim levels representative of current retail cuts. “This provided analytical data that had not previously been available in SR on beef cuts such as top loin steak, ribeye, top and bottom round, chuck, and brisket,” says Patterson.

Like the familiar Nutrition Facts labels on other foods, those on ground meats will include the number of calories and the amount of saturated fat, cholesterol, total fat, protein, sodium, total carbohydrates, vitamin A, vitamin C, calcium, and iron. “The nutrition information for the ground-meat packages and for the butcher-counter posters is based on the NDL data sets,” says Amy Cifelli, NCBA’s nutrient database improvement project manager. Additionally, any ground product that lists a lean percentage statement, such as “83 percent lean,” on its label will also list its fat percentage, making it easier for consumers to understand the amounts of lean protein and fat in their purchase. “NCBA is developing a web-based program that will help beef retailers produce the required Nutrition Facts labels and information,” says Cifelli. “And we are using the NDL meat data sets in the program.”

The USDA-FSIS rules were announced in a “Federal Register” notice. FSIS is the public health agency responsible for ensuring that the nation’s commercial supply of meat, poultry, and egg products is safe and correctly labeled and packaged.

The data sets for retail cuts of beef and pork provide retailers with easier access to the most accurate beef and pork nutrient data for the purpose of both on-pack and butcher-counter-posted nutrition labeling.



Nutrient Data Laboratory scientists review the revised USDA nutrient data sets for fresh pork and beef. From left to right are chemist Kristine Patterson, nutritionists Juhi Williams and Marybeth Duvall, and supervisory nutritionist Joanne Holden.

The data sets focus on the specific cuts identified by FSIS’s labeling regulations for fresh, single-ingredient meats and ground-meat products.

The beef and pork data sets are available online as both a PDF file and as a Microsoft Excel spreadsheet. Users such as retailers and industry can download the data sets, free of charge, onto a computer hard drive

and use the data in conjunction with other software programs.

The “USDA Nutrient Data Set for Retail Beef Cuts, Release 2.0” can be accessed at www.ars.usda.gov/services/docs.htm?docid=18961.

The “USDA Nutrient Data Set for Fresh Pork, Release 2.0” can be accessed at www.ars.usda.gov/services/docs.htm?docid=13467.

Other single-ingredient, raw-meat products to be updated with new Nutrition Facts labels include lamb, chicken, and turkey.—By **Rosalie Marion Bliss, ARS.**

This research supports the USDA priority of ensuring food safety and is part of Human Nutrition, an ARS national program (#107) described at www.nps.ars.usda.gov.

Joanne Holden is with the USDA-ARS Nutrient Data Laboratory, 10300 Baltimore Ave., Bldg. 005, Room 107, Beltsville, MD 20705-2350; (301) 504-0630, joanne.holden@ars.usda.gov.

COURTESY OF THE BEEF CHECKOFF (D2382-1)



Starting in January 2012, federal rules will require specific meat cuts, like this beef top sirloin steak, to carry nutritional facts information from data developed by scientists at ARS’s Nutrient Data Laboratory, in Beltsville, Maryland.

A Rough, Tough Forage for Rangeland Cattle

Forage kochia (*Kochia prostrata*) is a shrubby Asian native that has found a new home on western U.S. rangelands. And although it is not invasive, it is still sometimes more resilient than the North American native plants.

“In some rangeland soils, it’s difficult to successfully reseed with native plants,” says geneticist Blair Waldron, who works at the Agricultural Research Service’s Forage and Range Research Laboratory in Logan, Utah. “But we’ve shown that forage kochia can be established to enhance rangelands and compete with cheatgrass successfully. It can even protect against wildfires. Some people said that livestock won’t eat it, but we’ve found that cows will graze kochia—and that they even prefer it over lupine, which can be toxic to pregnant cattle.”

Waldron and his research partners have published findings that give ranchers even more reason to like the forage perennial. Their work compared how well cattle fared after two seasons of spending the fall and winter grazing on either kochia-dominated rangelands or grass-dominated rangelands.

“Winter feeding can account for 50 to 70 percent of a producer’s annual costs, so we wanted to see whether ranchers could save on

annual feed costs if their cattle have suitable rangeland plants to graze in the fall,” Waldron says.

The scientists investigated fall/winter rangeland forage yields, rangeland carrying capacities, nutritive values, and the livestock performance of cattle that grazed on both types of rangeland from late October until the following January. The commercial-scale, on-farm trials were funded in part with a grant from the Western Sustainable Agriculture Research and Education Program and were conducted in Tooele County, Utah, in cooperation with the Grantsville Soil Conservation District and the Darrell Johnson Ranch in Rush Valley.

After calculating the appropriate stocking rate, Waldron and his partners stocked each site mainly with Black Angus cattle and ran field trials in 2007 and 2008. The scientists found that the forage yield on rangelands seeded with kochia was 2,309 pounds per acre, which was 6 times greater than the forage yield on traditional grazinglands. This difference meant that the rangelands with kochia could support 1.38 animals per acre, while the traditional rangelands could support only 0.24 animals per acre. The experimental

forage had a crude protein content of 11.7 percent—well above the recommended

minimum—while the stockpiled grasses had a crude protein content of only 3.1 percent, which was below the recommended minimum.

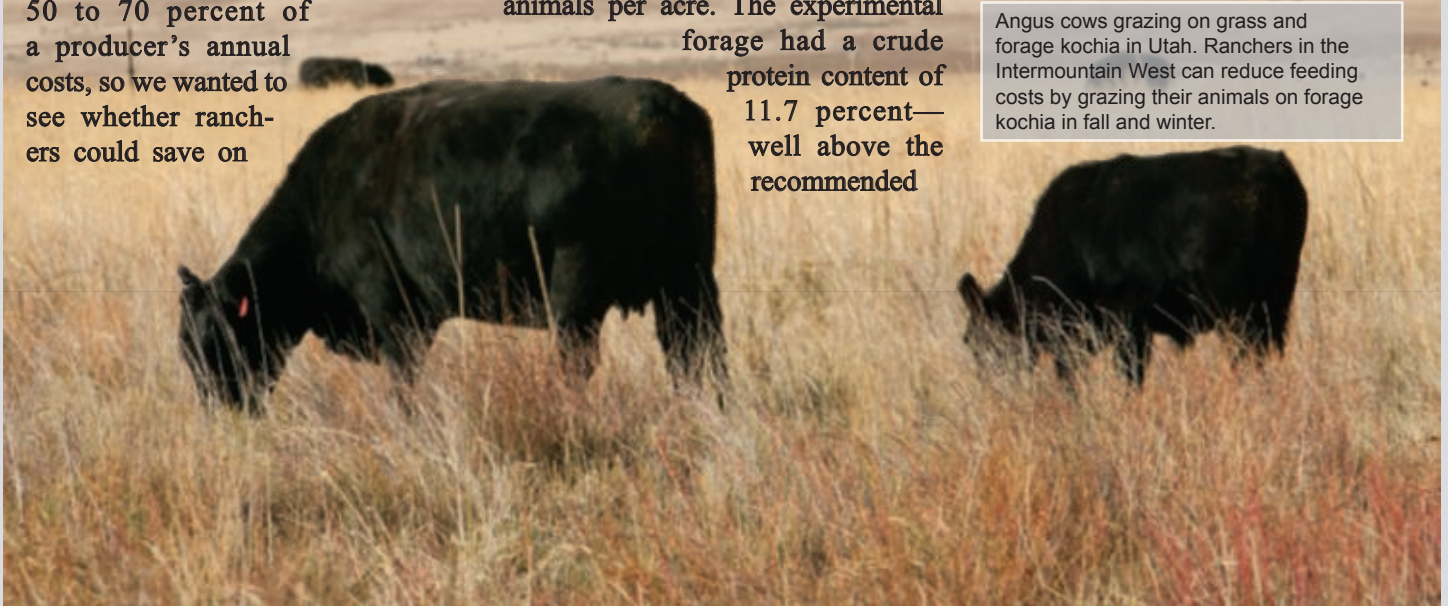
Waldron says this work shows that forage kochia can improve sustainable livestock production in the western United States by increasing rangeland carrying capacity and forage nutritive value.

“Now we’re using kochia varieties we collected from Uzbekistan and Kazakhstan to develop new cultivars that grow taller and have thicker stems, so they’ll be more accessible to cattle and wildlife in snow,” Waldron says. “We’re hoping to release an improved variety of kochia later this year.”—By **Ann Perry, ARS.**

This research is part of Pasture, Forage, and Rangeland Systems (#215) and Plant Genetic Resources, Genomics, and Genetic Improvement (#301), two ARS national programs described at www.nps.ars.usda.gov.

*Blair Waldron is with the USDA-ARS Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300; (435) 797-3073, blair.waldron@ars.usda.gov.**

Angus cows grazing on grass and forage kochia in Utah. Ranchers in the Intermountain West can reduce feeding costs by grazing their animals on forage kochia in fall and winter.



PEGGY GREB (D368-16)

The Agricultural Research Service has labs all over the country.

Locations Featured in This Magazine Issue



San Joaquin Valley Agricultural Sciences Center, Parlier, California

3 research units ■ 117 employees

Eastern Oregon Agricultural Research Center, Burns Oregon

1 research unit ■ 44 employees

The Vegetable and Forage Crops Research Unit, Prosser, Washington

1 research unit ■ 39 employees

Northwest Irrigation and Soils Research Laboratory, Kimberly, Idaho

1 research unit ■ 40 employees

Logan, Utah

3 research units ■ 100 employees

Las Cruces, New Mexico

2 research units ■ 54 employees

Ames, Iowa

8 research units ■ 535 employees

Little Rock, Arkansas

9 research units ■ 67 employees
(1 ARS employee, 66 university employees)

National Center for Agricultural Utilization Research, Peoria, Illinois

7 research units ■ 226 employees

Jamie Whitten Delta States Research Center, Stoneville, Mississippi

7 research units ■ 323 employees

Oxford, Mississippi

3 research units ■ 102 employees

Urbana, Illinois

2 research units ■ 46 employees

Tifton, Georgia

3 research units ■ 118 employees

Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, FL

4 research units ■ 144 employees

Coastal Plains Soil, Water, and Plant Research Center, Florence, South Carolina

1 research unit ■ 36 employees

Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, Maryland

30 research units ■ 953 employees

Map courtesy of Tom Patterson,
U.S. National Park Service



U.S. Department of Agriculture
 Agricultural Research Magazine
 5601 Sunnyside Ave.
 Beltsville, MD 20705-5129

PRST STD
 Postage and Fees Paid
 U.S. Department of Agriculture
 Permit No. G-95

Official Business

Please return the mailing label
 from this magazine:

To stop mailing _____

To change your address _____



Subscribe

for \$60.00 per year
 (\$84.00 foreign
 addresses)
 Visa and Mastercard
 accepted.
 Prices subject to change.
 Order By:
 Fax: (202) 512-2104
 Phone: (202) 512-1800
 Mail:
 New Orders
 Superintendent of
 Documents
 P.O. Box 371954
 Pittsburgh,
 PA 15250-7954
bookstore.gpo.gov

Visit us on the Web at ars.usda.gov/ar