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USDA
United States Department of Agriculture

August 2013

# Agricultural Research

## The Magic of Microscopy

Story on pages 10-12

Agricultural Research Service • *Solving Problems for the Growing World*

# FORUM

## Novel Ways To Combat Plant Pathogens

Plant diseases must be managed to successfully and reliably produce crops to meet humanity's growing food, fiber, feed, and fuel needs. Plant disease management relies on many different types of tools—from disease-resistant plant varieties and pesticides to cultural and biological strategies. Agricultural Research Service scientists are seeking new methods of managing plant diseases, more efficient means of using older methods, and combinations of these methods. Two of the oldest ways of reducing plant diseases are crop rotation and organic amendments to soil.

In Orono, Maine, for example, ARS scientists are evaluating a holistic approach to suppressing soilborne pathogens of potato, including 2- and 3-year rotations with barley, ryegrass, canola, and rapeseed. In one study, the regimen reduced the incidence of *Rhizoctonia* by as much as 50 percent. They also examined the effectiveness of biological soil amendments, such as compost tea (compost steeped in water) and cover crops of winter rye, against various types of scab, black scurf, and other potato diseases. (See story in the next issue.)

Historically, heat has been used to rid plants of some pathogens—at temperatures and durations that won't damage the plants in the process. Indeed, in Fort Pierce, Florida, ARS researchers are evaluating such a method to rid citrus seedlings of the bacterial agent that causes Huanglongbing (HLB), also known as "citrus greening." The citrus disease has caused serious economic losses in the "Sunshine State" and in other citrus-growing regions of the world for decades. The disease weakens, and can eventually kill, afflicted trees as well as render their fruit unmarketable.

The Fort Pierce team found that heating potted citrus seedlings in growth chambers for periods ranging from 2 to 10 days reduced or eliminated HLB infection. They found that all of the heat treatments were equally effective, regardless of temperatures and exposure times. The next step is to adapt these methods for field applications. (See story that begins on page 4.)

Biological control—the use of beneficial microbes, insects, or other organisms to reduce populations of insect pests or plant pathogens—is another crop-protection strategy. In Peoria, Illinois, ARS researchers are evaluating this method as a way to slow the spread of two fungal pathogens of avocado (*Raffaelea* and *Fusarium*) that are disseminated, or "vectored," by small ambrosia beetles.

Although these beetles cause damage on their own, the fungi they transmit can kill avocados. So, in addition to attacking the beetles with biocontrol agents, the team is also targeting the fungi, which the beetles cultivate inside the trees—and which cause diseases that threaten America's $322-million avocado crop. (Story on page 20.)

Plant viruses commandeer the cellular machinery of plants to replicate and spread—typically at great cost to their host's health and productivity. But what if that same cell-infecting ability could be turned to good use? That's a question ARS researchers in Beltsville, Maryland, are working to answer. They're exploring approaches for using certain viruses to genetically transform plants into "bio-factories" capable of making therapeutic products, including antimicrobial peptides and animal vaccines. Plant-based vaccines are an especially intriguing prospect because of the potential for greater availability, lower production costs, ease of use in immunizing large numbers of livestock animals, safety advantages, and other benefits.

Under the Plant Diseases national program and other ARS national programs, ARS researchers collaborate with university scientists, private industry, and other partners in efforts to sequence the genomes of major crop pathogens, including *Phytophthora infestans*, which causes potato late blight, *Fusarium graminearum*, the culprit behind wheat scab, and *Candidatus* Liberibacter asiaticus, which causes HLB in citrus.

Genome mapping can shed new light on how pathogens cause disease, evade host defenses, or reproduce and spread. It can also reveal weak links that can be exploited to design novel controls that mitigate yield and quality losses in host crops. Another focus is developing sensitive, easy-to-use, and reliable diagnostic assays to detect and identify pathogens. Some of these can identify multiple pathogens simultaneously and return results within hours or minutes of processing a sample. This capacity can be critical to decisionmaking in both the field and at regulatory agencies charged with safeguarding agriculture and natural resources.

Computer modeling, epidemiology, bioinformatics, and other fields of study also figure prominently in ARS's plant diseases research program, which prioritizes crop pathogens for study by their high impact on crops and producers' incomes, regulatory or quarantine significance, importance to national biosecurity, and usefulness as a model organism for understanding other pathogens.

ARS research program areas are designed to be crosscutting and collaborative, and the Plant Diseases national program is no exception. It will continue to draw on and complement the strengths of other research programs in responding to stakeholder needs in a manner that is timely, relevant, and sustainable, both environmentally and economically.

**Deborah Fravel and Gail C. Wisler**
ARS National Program Leaders
Crop Production and Protection
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# Agricultural Research

Solving Problems for the Growing World

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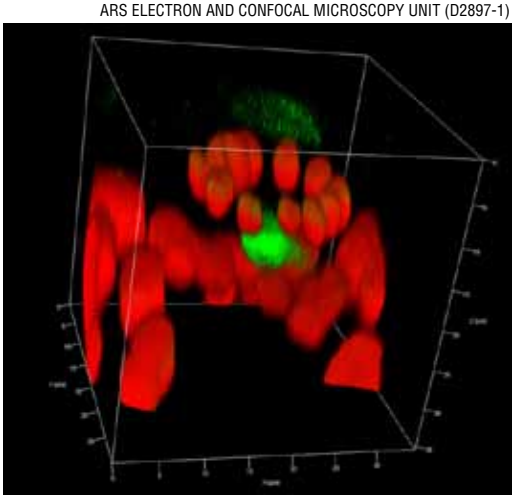
ARS ELECTRON AND CONFOCAL MICROSCOPY UNIT (D2897-1)



A three-dimensional image, constructed from a series of images taken with a confocal fluorescence microscope, of a *Cryptosporidium* oocyst (bright green) inside a stoma (pore) of a spinach plant. The red spheres surrounding the oocyst are the plant's chloroplasts. Story begins on page 10.



Cover: Colorized scanning electron micrograph of a pair of red palm mites. Richly detailed images like this one allow scientists to accurately identify microscopic organisms and learn more about their features, physiology, and actions. Story begins on page 10. Photo by the ARS Electron and Confocal Microscopy Unit. (D2887-1)

# Prescription for Curing Citrus Greening

TIM GOTTWALD (D2938-1)

SCOTT BAUER (K11953-1)

Left: Orange tree leaves with some symptoms of Huanglongbing, or citrus greening, for which there is no known cure or commercially viable treatment.

**Huanglongbing (HLB), or citrus greening,** is the most serious threat to the Florida citrus industry in its history and is costing millions of dollars each year. Working with the Florida Department of Agriculture and Consumer Services (FDACS), Yongping Duan and his Agricultural Research Service colleagues in Fort Pierce, Florida, have found a formula for curbing HLB, offering the industry a glimmer of hope.

Duan has published details of work showing that heating potted citrus seedlings in greenhouses kills off the HLB bacterium and can rid the seedlings of citrus greening symptoms. Monitoring efforts show that the benefit can last for at least 2 years.

In a separate field trial, Duan has also found that heating HLB-infected trees in the sun by encasing them in plastic "tents" can prolong their productivity. Results of the field trials have yet to be published, but Duan says heating trees in solar tents may offer relief to growers whose citrus groves are being devastated. "We can't guarantee 100-percent elimination, but it can keep production up for longer periods," Duan says.

When a citrus tree is infected with the HLB bacterium, the pathogen resides inside the tree's phloem tissues and blocks the passage of nutrients through its vascular system, making the tree unproductive. Infected trees can survive for 3 to 5 years, but fruit that doesn't fall to the ground prematurely is often misshapen and sometimes will only partially ripen, making it unmarketable. There is no known cure for HLB and no commercially viable, effective treatments. It remains a threat not only to the citrus industry in Florida, where it was discovered in 2005, but to citrus-producing states nationwide.

### Three Temperature Settings, Same Results

In the greenhouse experiments, Duan and his ARS colleagues Michele Hoffman, Melissa Doud, David Hall, and Ed Stover, along with FDACS scientists, exposed 30 HLB-infected citrus seedlings to different levels of heat in growth chambers for periods ranging from 2 days to 10 days. The seedlings were about 2.5 years old, about 2 feet in height, and were growing in

Following heat treatment in plastic tents (shown in photo at top of page 5), these Huanglongbing-infected orange trees appear nearly symptom free and productive.

MARCO PITINO (D2937-1)

# Apply Heat and Wait

ARS plant pathologist Yongping Duan (left) and postdoctoral assistant Melissa Doud examine a tree that was previously under a tent (like the one on the left) for heat treatment to combat citrus greening. The technique significantly reduces disease symptoms and improves tree productivity.

1-gallon containers. They were divided into three groups and heated to 104˚F, 107˚F, or 113˚F. Fluorescent lamps provided light for 12-hour "days" and were turned off for 12-hour "nights."

MARCO PITINO (D2935-1)

For comparison, the researchers also applied the heat treatments to citrus budwood and periwinkle, which is also susceptible to HLB. They used PCR technology, which amplified the pathogen's DNA, to measure the HLB pathogen levels in the trees, budwood, and periwinkle. Infection levels were measured a week before heat treatments began and again 30, 60, and 270 days after they ended.

The researchers quickly learned that constant exposure to temperatures of 113˚F or higher would defoliate citrus seedlings. But if they interrupted the steady onslaught of intense heat by dropping temperatures down to about 80˚F for at least 5 hours each day, the leaves stayed alive.

Results from the greenhouse tests, published in the journal *Phytopathology*, also showed that exposing citrus seedlings to a minimum of 48 hours of temperatures of 104˚F to 107˚F significantly reduced, and often eliminated, HLB infection. All of the heat treatments were equally effective, regardless of temperatures and exposure times. The researchers continued to test the seedlings, and after 2 years of heat treatments, they have remained free of HLB.

"This application would be useful for nurseries and greenhouses and rescue of germplasm that's been infected," Duan says.

By contrast, exposing newly grafted budwood to alternating temperatures of 102˚F and 86˚F for up to 4 months did not reliably cure it. The heat controlled the HLB in periwinkle, but the periwinkle plants were more heat tolerant than the citrus trees and required more prolonged heat for infection levels to be reduced.

### Heating Trees in Tents

Another approach to controlling HLB damage may have wider implications by prolonging the productivity of full-grown citrus-producing trees. Florida citrus

SCOTT BAUER (K7226-29)

grower David McKenzie, working with Duan, has been encasing citrus trees in opaque, plastic PVC "tents" to heat them up for about a week, then removing the tents and trimming off the top 10 or 12 inches of the trees that have been "browned up" by the solar heat.

The results have been striking. Within short periods of time, leaves stunted by HLB begin to flourish, and by the time the fruit is ready for harvest, its quality is noticeably improved.

"The flush [leaf growth] after the tents are removed is phenomenal. The leaves start to flush about 2 to 4 weeks after the tent is removed, and that flush will peak after about 6 weeks," McKenzie says.

McKenzie has been using the tents for about a year and a half, applying them from April to September. He has covered about 1,000 of his 130,000 trees, working in alternating 20-acre blocks and tenting about 5 trees at a time in each block. He selects trees with moderate HLB symptoms (smaller, shriveled fruit and stunted leaves) that are about 3 to 6 years old and 6 feet high. He uses cinder blocks to hold the tents in place and positions the tents so their tops are near the tops of the trees and they drape closely around the tree circumference. That way, by mid afternoon the heat in the tents reaches about 125˚F near the treetops and about 110˚F near the base.

"Once trees reach a certain size, maybe to where they have a 25-foot circumference, that's about the maximum size for using the tent. What is important is for the top of the tent to be close to the top of the tree, so you have heat at the top," McKenzie says.

Tents can be reused, and McKenzie estimates that with labor, the system costs about $45 per tent. He says the results are worth the effort.

"We're finding that the trees we tented last year don't need to be tented this year. Trees with major symptoms before the treatment have minor symptoms after treatment, and the trees are producing normal fruit where they were producing small fruit before," McKenzie says.

As with the potted citrus, Duan is unsure about the specific biological causes underlying the results. HLB is a systemic disease, and eliminating it from a tree generally requires eliminating it from the roots. The heat doesn't entirely kill off the HLB in the tree, but it seems to weaken the infection process and prolong the tree's productive life.

"It works better if the infection is in its early stages and the bacteria have not yet reached the plant root," Duan says.

The results of Duan's field trial at McKenzie's groves are not yet published. But Duan is promoting them along with the growth chamber results in scientific conferences and meetings with growers and nursery operators. The work has been partially funded by FDACS and the Citrus Research and Development Foundation.

Growers are beginning to consider the approaches, where practical, and McKenzie is enthusiastic about the results.

"Do I think it works? Absolutely I do. It's encouraging. It makes me think that with all the damage we're seeing from citrus greening in Florida, we're staying in the game," McKenzie says.—By **Dennis O'Brien,** ARS.

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

*Yongping Duan is in the USDA-ARS U.S. Horticultural Research Laboratory, 2001 South Rock Rd., Fort Pierce, FL 34945; (561) 462-5840, yongping.duan@ars.usda.gov.**

Trees infected with citrus greening, but not treated with heat, have obvious disease symptoms and reduced productivity.

MARCO PITINO (D2936-1)

# Screening Fresh Oranges With UV

## Study Pinpoints New Value of Detection Tactic

**Fresh, deliciously sweet navel oranges,** on display at your local supermarket, may have been quickly inspected with ultraviolet (UV) light when they were still at the packinghouse. Usually, the purpose of this special sorting and screening is to see if circular spots—which glow a bright, fluorescent yellow and may be about the size of a quarter or larger—show up on the fruit's peel.

More often than not, these spots, which scientists refer to as "lesions," are telltale indicators of the presence of microbes that cause decay, namely *Penicillium italicum*, responsible for blue mold, or *P. digitatum*, the culprit behind green mold.

It isn't the microbes that are fluorescing under the packinghouse UV lamps. Instead, it's tangeritin, a natural compound in citrus peel oil. When the peel is damaged, such as by decay, tangeritin moves closer to the peel surface, or perhaps seeps out of it, becoming easier for UV to detect.

The characteristic "fluorescence signature" of the decay lesions is easily recognized by packing-line workers who monitor the fruit as it speeds past them on a conveyor belt. All navel oranges that display this distinctive pattern are promptly culled—an established practice that dates back more than 50 years in California citrus packinghouses.

But studies by plant physiologist Dave Obenland and plant pathologist Joe Smilanick—both with the Agricultural Research Service in Parlier, California—suggest that other, less-studied patterns of fluorescence on navel orange peels may warrant more attention. Fluorescence in the form of specks, smears, smudges, or blotches, for example, may indicate the presence of cuts, punctures, or other peel wounds that might not be visible to the naked eye, yet may pave the way to attack by decay microbes.

To learn more about these less-familiar patterns, the researchers sampled about 5,000 navel oranges over a 2-year period. For the study, navel oranges sampled at two California citrus packinghouses were sorted by fluorescence level—zero, sparse, moderate, or high—noted during UV screening. Next, the oranges were evaluated twice under normal light—not UV. The first time was within 24 hours after UV screening and sorting; the second was after the oranges had been stored at 59ºF for 3 weeks.

As expected, fruit with high fluorescence developed further decay and peel-quality problems during storage—but so did many of the oranges that had only moderate fluorescence.

Taken as a whole, the findings suggest that packers might want to expand UV screening to take several fluorescence levels and patterns into account when sorting navel oranges. Many of the patterns that the researchers investigated, such as glowing specks no bigger than the tip of a ballpoint pen, might be quickly and easily detected with modern UV-equipped machine-vision sorters.

The idea of expanding UV use to include more than detection of the classic decay signature is not new. But the Parlier study, though preliminary, is likely the first to present as detailed a look at this approach.

ARS and the grower-sponsored California Citrus Research Board, in Visalia, funded the research.

Obenland, Smilanick, ARS plant pathologist Dennis Margosan at Parlier, and ARS statistician Bruce Mackey at Albany, California, documented the UV findings in a 2010 peer-reviewed article in *HortTechnology*.—By **Marcia Wood,** ARS.

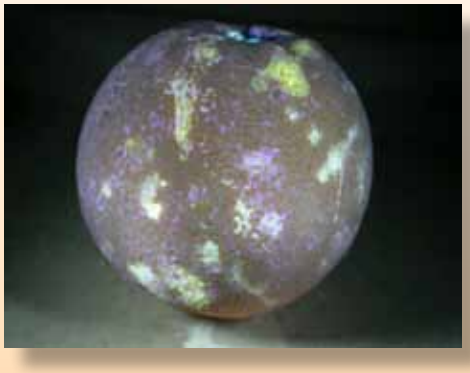
*Top:* During ultraviolet (UV) screening at citrus packinghouses, navel oranges that display the characteristic "fluorescence signature" associated with the presence of blue or green mold are typically culled. *Middle:* Oranges with less-studied patterns, such as blotches, may also warrant attention, ARS research has shown. *Bottom:* ARS plant physiologist Dave Obenland examines oranges under UV light at a citrus packinghouse.

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

*David M. Obenland and Joseph L. Smilanick are at the USDA-ARS San Joaquin Valley Agricultural Sciences Center, 9611 S. Riverbend Ave., Parlier, CA 93648; (559) 596-2801 [Obenland], (559) 596-2810 [Smilanick], david.obenland@ars.usda.gov, joe.smilanick@ars.usda.gov.**

DAVID OBENLAND (D2927-1)

DAVID OBENLAND (D2926-1)



JEANNETTE WARNERT (D2928-1)

# Breed Matters

## Selecting Rams for Rangeland Production

PHIL PURDY (D2929-2)

Columbia rams.

MICHELLE MOUSEL (D2931-1)

PHIL PURDY (D2930-2)

Suffolk rams.

In western states, where almost half of U.S. sheep are produced, the Suffolk ram is commonly used as the "terminal sire"—an animal with the best genetics to sire lambs for meat production. However, concerns about the ability of Suffolk-sired lambs to survive from birth to weaning, and then to harvest, raised some doubts about the Suffolk's value as a terminal sire.

Western producers are challenged by diverse management systems and production environments. Therefore, they need a comprehensive evaluation to help identify terminal-sire breeds best suited for their operations.

Scientists at the Agricultural Research Service's U.S. Sheep Experiment Station (USSES) near Dubois, Idaho, examined four breeds used to produce market lambs. The team, which included scientists from Virginia Tech, Ohio State University, and the ARS Roman L. Hruska U.S. Meat Animal Research Center (USMARC) in Clay Center, Nebraska, studied critical performance traits of lambs sired by rams of Columbia, Suffolk, and Texel breeds and by a composite breed developed at USMARC. Scientists evaluated lamb survival from birth to weaning; growth before and after weaning; changes in body composition, such as fat and muscle relationships; efficiency of growth; and carcass merit and value.

### From Birth to Weaning

"Our objective was to evaluate U.S. sire breeds side by side in an extensive rangeland production system," says ARS geneticist Tim Leeds. "Does breed of ram affect whether a ewe will become pregnant, how many lambs a ewe will produce, and performance of the progeny from birth until weaning?"

Scientists first determined the effects of ram breed on ewe reproduction, lamb survival, and lamb growth through weaning. They mated approximately 20 rams per breed to 574 Rambouillet ewes over a 3-year period. More than 1,800 lambs, produced from almost 1,000 matings, were subsequently evaluated.

"Breed of sire affected lamb growth from birth to weaning, but not survival," Leeds says. "As suspected, Suffolk-sired lambs were larger at birth, so they grew faster—gaining 3 to 6 pounds more before weaning—and their survival was as good as or better than that of the other crossbred lambs."

### Suffolk Gains in Other Traits

After weaning, lambs were fed a high-energy diet in a feedlot and weighed weekly. Ultrasound measurements were taken every 2 weeks to determine fatness and muscle development during the feeding period.

"Suffolk-sired lambs had the most rapid gains, were 10 to 16 pounds heavier, and had the most desirable leanness at the end of the postweaning feedlot trial," says David Notter, professor emeritus in the Department of Animal and Poultry Sciences at Virginia Polytechnic Institute and State

Left: Technician Tracy Northcutt uses diagnostic ultrasound to determine fat level and muscle development of lambs.

University. "They were equal or superior to lambs sired by the other breeds in growth, fat depth, and loin muscle area."

"Columbia-sired lambs had the least amount of back fat and the smallest loin muscle area compared with lambs produced by the other breeds," adds USSES geneticist Michelle Mousel. "Producers want to see larger loin muscle. But Columbia's leanness could be an advantage for consumers."

DAVID NOTTER (D2940-1)

DAVID NOTTER (D2941-1)

**Top:** Texel rams. **Bottom:** MARC composite rams.

Breeds were also examined for feed efficiency, which refers to how well lambs convert feed into growth, says USSES geneticist David Kirschten.

"Suffolk-sired lambs were the most efficient during the study," Kirschten says. "They required between 5 and 8 percent less feed per unit of growth during 90 days in the feedlot than the other three breed crosses. Columbia-sired lambs required more than 15 pounds of additional feed compared with lambs from the other sire breeds at comparable body weights and rates of gain."

After lambs had reached prescribed market weights, carcass value and organ weight were evaluated with the help of Ohio State University scientists, who harvested animals and cut meat into marketable products.

"Because Suffolk-sired lambs were heavier at birth, weaning, and at completion of the feedlot trial, they also had heavier carcass weights, more kidney fat, and larger loin muscle area, although pound for pound, Texel-sired lambs were as well muscled as the Suffolk-sired lambs," Mousel adds.

### Going Head to Head

Even though Suffolk-sired lambs were a cut above the three other crossbred groups for most traits, the other sire breeds still may have something to offer, according to scientists. Each sire breed has its own distinctive characteristics. For example, Texel-sired rams can be used to produce heavily muscled lambs that are ready for market at younger ages than Suffolk-sired lambs. Columbia-sired lambs may be marketed at older ages than Texel-sired lambs, without becoming too fat. USMARC composite-sired lambs may be ready for market at an intermediate age, size, and degree of fatness and muscling.

"Producers can use information from this study to help select sire breeds that will complement their production systems and improve the market value of lambs," Mousel says. "The take-home message is to know what weaning and market weights you want, what to feed your lambs, what type of environment they're reared in, and what breed of ewe you are going to use."

"Because the Columbia didn't do nearly as well as the Suffolk, Columbia breeders may need to adjust their selection criteria, focusing more on growth and muscling if they wish to compete with the Suffolk as a specialty terminal-sire breed," Notter says. "But producers also value the dual-purpose capability and wool quality of the Columbia and may prefer to use it as both a maternal and sire breed."

The USMARC composite, developed as a genetic resource rather than a terminal-sire breed, has been surpassed by purebreds in terms of performance potential, Notter says. But it may have some use in stressful production environments that favor a lamb with intermediate growth potential that can be marketed at an intermediate weight.

"The Texel has a role to play typically if animals are harvested at lighter weights or under less intensive feeding," he says. "It might also have value in developing germplasm for future use."

### Potential for New Breeds

Scientists are developing new germplasm resources based on crosses among the Suffolk, Columbia, and Texel breeds. They hope to capture the growth traits of Suffolk, muscling traits of Texel and Suffolk, and fleece traits of Columbia and incorporate those traits into a higher performance terminal-sire breed that produces large, heavily muscled, efficiently growing lambs with all-white pelts.

"All-white pelts, which are used to produce high-quality apparel, are usually more valuable than pelts with dark colored fibers," says recently retired USSES research leader Greg Lewis.

"We can use breed diversity in terminal crossbreeding systems to improve production efficiency," Lewis says. "The recent data can be used to select terminal-sire breeds to accomplish specific production and marketing objectives and to develop composite genetic lines that incorporate the most favorable traits of different breeds. Composite genetic-sire lines that are suitable for challenging rangeland production systems have the potential to compensate for deficiencies in the current breeds."—By **Sandra Avant,** ARS.

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

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# Scientific Works of Art Reveal

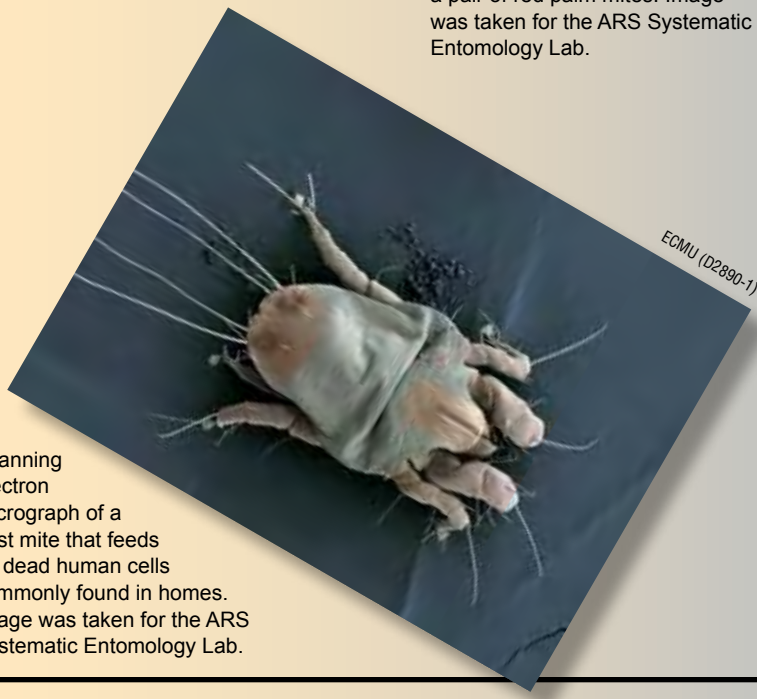
ECMU (D2886-1)

Scanning electron micrograph of a purple, red-eyed predatory mite, found on soil while hunting for small insects and mites. Image was taken for the ARS Systematic Entomology Lab.

ECMU (D2887-1)

Scanning electron micrograph of a pair of red palm mites. Image was taken for the ARS Systematic Entomology Lab.

ECMU (D2890-1)



Scanning electron micrograph of a dust mite that feeds on dead human cells commonly found in homes. Image was taken for the ARS Systematic Entomology Lab.

It's been said that a picture is worth a thousand words, and at the Agricultural Research Service's Electron and Confocal Microscopy Unit (ECMU) in Beltsville, Maryland, this adage couldn't be more true. Led by unit director Gary Bauchan, the ECMU is tasked with producing high-resolution images that provide a window to the extraordinary world of the unseen.

"We have observed viruses, bacteria, fungi, nematodes, insects, mites, and parasites that threaten global food security, and we've contributed to the discovery of how pathogens spread by helping elucidate their relationship to the environment, hosts, and vectors," says Bauchan. "We've also described new biocontrol agents for the management of pathogens and characterized healthy and infected plant and animal tissues to discern the structural changes caused by pathogens."

Other ECMU capabilities include tracking the development of genetically transformed plants using fluorescently tagged plant cells and tissues and contributing to improved food safety by determining the mechanisms by which bacteria, fungi, and parasites infect fresh produce.

Scientists conducting multifaceted studies at ARS's Beltsville Agricultural Research Center (BARC) routinely call upon the microscopy experts in the unit to image all manner of specimens and samples. The researchers benefit not only in furthering their research objectives, but also by obtaining images to illustrate their journal articles, journal covers, grant proposals, web pages, and poster presentations.

Microscopy images in this story were photographed and colorized by the ARS Electron and Confocal Microscopy Unit (ECMU), located in Beltsville, Maryland.

# a Hidden World

Needless to say, the microscopy unit's services are in high demand and greatly appreciated. The latter was apparent from the turnout of BARC scientists and others who attended an October 11, 2012, ribbon-cutting ceremony presided over by Bauchan and Beltsville Area Director Joseph Spence. The event marked the completion of 2 years of renovations to the climate-controlled building that houses the ECMU and its prized collection of multi-million-dollar microscopes. Those include a low-temperature scanning electron microscope (LTSEM), a variable-pressure scanning electron microscope, two transmission electron microscopes, a confocal laser-scanning microscope (CLSM), and a Hirox digital video microscope. All are equipped with state-of-the-art digital cameras to speed the delivery of resulting images to researchers.

The ribbon-cutting ceremony also was in recognition of the expertise, creativity, and resourcefulness with which Bauchan, ECMU support scientists Charlie Murphy and Margaret Dienelt, and information technology

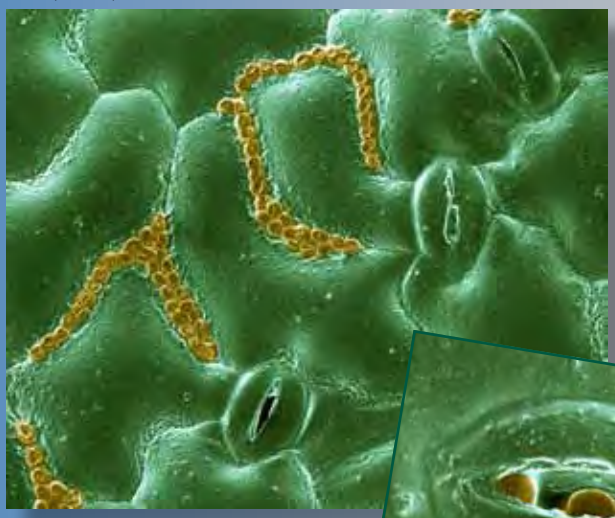
STEPHEN AUSMUS (D2902-2)

In the ARS Electron and Confocal Microscopy Unit, in Beltsville, Maryland, (left to right) support scientist Charlie Murphy and entomologist Ron Ochoa observe a red velvet mite with a digital video camera microscope while lab director Gary Bauchan, plant pathologist John Hammond, and IT specialist Chris Pooley use a confocal laser scanning microscope to view tobacco leaves after gene insertion.

ECMU (D2885-1)

Scanning electron micrograph of a bean rust pustule ready to burst with infectious spores. Image was taken for the ARS Soybean Genomics and Improvement Lab.

ECMU (D2891-1)



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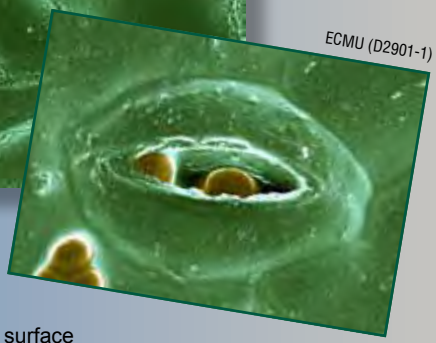
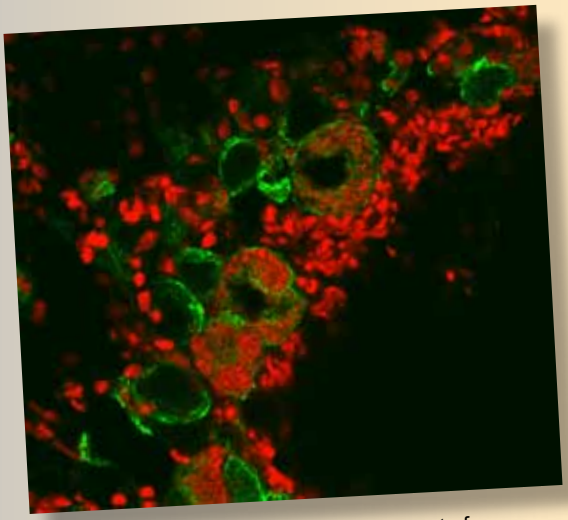


Scanning electron micrograph (SEM) of several *Cryptosporidium* oocysts (animal parasites, gold colored here) inoculated onto the surface of spinach to determine where they will settle. **Inset:** SEM of a *Cryptosporidium* oocyst in a spinach leaf stoma. Both images were taken for the ARS Environmental Microbiology and Food Safety Lab.

ECMU (D2896-1)



Fluorescent confocal micrograph of the gut of a chicken with large cells containing intestinal parasites. Image was taken for the ARS Animal Parasitic Diseases Lab.

ECMU (D2889-1)

Scanning electron micrograph showing the highly ornamented skin of the rear leg of a rare soil mite. Image was taken for the Systematic Entomology Lab.

specialist Christopher Pooley produce the images (at magnifications of up to 300,000 times) and ensure the integrity of the specimens for analysis by the researchers who submit them.

For example, when John Hammond, a plant pathologist at the U.S. National Arboretum's Floral and Nursery Plants Research Unit, contacted the team for assistance, the result was a three-dimensional image of how viruses spread from leaf veins to adjacent leaf cells. The image, which was generated using fluorescently tagged viruses and a Zeiss 710 CLSM, accompanied an article in the August 2012 issue of the *Journal of General Virology* and illustrated the cover of the November 2012 issue.

Each of the unit's microscopes offers unique capabilities and requires special handling to prepare specimens and samples prior to imaging. For systematic studies of mites, an LTSEM can be used. This necessitates flash-freezing a mite specimen (while still alive) at -321˚F and coating it with platinum. In essence, the procedure freeze-frames the mite in time, allowing detailed examination of its features, physiology, behavior, and interaction with its immediate surroundings.

Imparting color to the high-magnification images helps further reveal critical, but often subtle, morphological differences between mite species, such as the size, shape, or number of setae (sensory organs) on their bodies. This capability has already proven invaluable to Beltsville scientists working with visiting scientist Jenny Beard, from the Queensland Museum in Australia, to differentiate species of mites in the genus *Raoiella*, members of which pose a significant threat to crops worldwide, including species of palm in the United States.

"At the Systematic Entomology Laboratory [SEL], our mite identifications support APHIS [USDA's Animal and Plant Health Inspection Service] plant protection and quarantine efforts, state agricultural agents, extension agents, and other countries looking for information and help on mite pests that affect their crops—or crops they export to our country," says mite expert Ron Ochoa, an ARS entomologist.

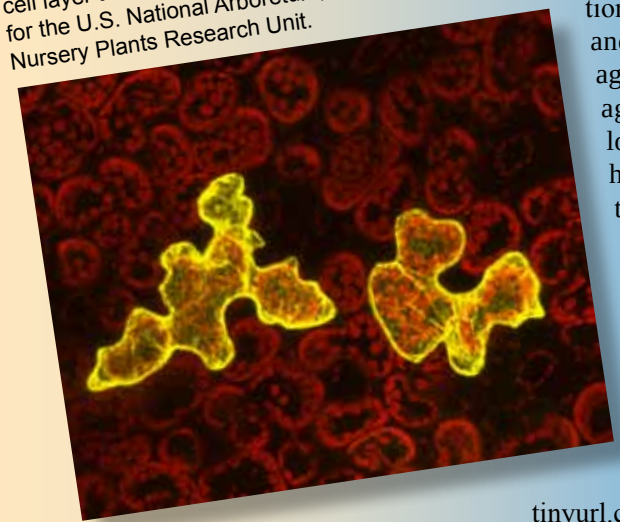
Images developed by SEL and ECMU have been used to develop an online identification key for flat mites of the world, tinyurl.com/flatmites. One year after the March 2012 launch of this website, there had been more than 86,392 visits to the web page, with inquiries from 196 countries. Ochoa notes that having access to the images is especially critical in making identifications that can become the impetus for regulatory decisions aimed at safeguarding U.S. agriculture, such as whether to treat, quarantine, or reject an agricultural import.

Bauchan estimates that the ECMU collaborated on 40 different projects last year, and 2013 looks to be just as busy—not only in literally answering the call of science, but also capturing it visually, as the sampling of images illustrating this article can attest.—By **Jan Suszkiw,** ARS.

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

*Gary Bauchan is in the USDA-ARS Electron and Confocal Microscopy Unit, Soybean Genomics and Improvement Laboratory, 10300 Baltimore Ave., Beltsville, MD 20705-2350; (301) 504-6649, gary.bauchan@ars.usda.gov.*

Confocal micrograph of epidermal cells of a plant infected with a virus fluorescently labeled (yellow) to show virus movement from cell to cell within a leaf. Red spheres are chloroplasts from a second cell layer that's not infected. Image was taken for the U.S. National Arboretum, ARS Floral and Nursery Plants Research Unit.



ECMU (D2892-1)

Confocal micrograph of a soybean cell having two different genes inserted into it, each with a different color fluorescent tag. One attaches primarily to the nucleus (red) and the other to the cytoplasm (green). Image was taken for the Soybean Genomics and Improvement Lab.

ECMU (D2893-1)

# ARS Validates Soil Moisture Data Collected Via Satellite

**The European Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission** includes the latest advance in using Earth-orbiting satellites for estimating soil moisture across the globe. The SMOS satellite was launched in 2009 and was designed to estimate soil moisture levels to within 4 percent, which is like measuring a teaspoon of water in a handful of dry soil.

To capture this data, SMOS uses a new sensor technology that is the first passive L-band system—measuring microwave radiation emitted around the frequency of 1.4 gigahertz—in routine operation. But the accuracy of the information collected by this new technology still needs to be verified with actual soil moisture measurements, a task perfectly suited for a team of Agricultural Research Service scientists.

In 2002, ARS scientists established soil moisture monitoring networks in four of the agency's long-term experimental watersheds to verify the accuracy of soil moisture data collected by other Earth-orbiting satellites. The researchers have been monitoring soil moisture levels in these networks—located in ARS watersheds at Walnut Gulch, Arizona; Little Washita, Oklahoma; Little River, Georgia; and Reynolds Creek, Idaho—hourly since 2002. So they had a vast amount of data from a range of environments they could use to validate SMOS soil moisture measurements.

STEPHEN AUSMUS (K10756-1)

Tom Jackson and collaborators collect an array of ground observations to verify the accuracy of satellite data.

The research team was led by ARS hydrologist Tom Jackson of the Hydrology and Remote Sensing Laboratory in Beltsville, Maryland. The team compared a year's worth of soil moisture data collected by SMOS with data from the four ARS watersheds and from another satellite system.

The researchers determined that the SMOS soil moisture estimates approached a 95-percent rate of accuracy, and they also identified conditions that reduced accuracy. For instance, SMOS records measurements in the early morning as the satellite ascends over the horizon and in the late afternoon as the satellite is descending. Rain showers generated from heat and moisture that had accumulated in the atmosphere throughout the day would often saturate the upper soil levels in the afternoon. These strong downpours would result in an overestimation of soil moisture by the SMOS sensors. Jackson's team devised a method for flagging and adjusting the data to improve the accuracy of the resulting soil moisture estimates.

STEPHEN AUSMUS (K10757-1)

ARS hydrologist Tom Jackson and student Parmecia Jones use different methods to test soil moisture. The measurements will be compared to see which more accurately validates data obtained via satellites.

Other ARS researchers contributing to this project include Michael Cosh, from the Beltsville lab; Patrick Starks, at the Grazinglands Research Laboratory in El Reno, Oklahoma; David Bosch, at the Southeast Watershed Research Laboratory in Tifton, Georgia; Mark Seyfried, at the Northwest Watershed Research Center in Boise, Idaho; and Susan Moran and David Goodrich, both from the Southwest Watershed Research Center in Tucson, Arizona.

The scientists published their findings in 2012 in *IEEE Transactions on Geoscience and Remote Sensing.*—By **Ann Perry,** ARS.

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

*To reach scientists in this story, contact Ann Perry, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5128; (301) 504-1628, ann.perry@ars.usda.gov.*

# New Strategies To Thwart Pecan Scab

Pecans are great for eating out of the shell or in a myriad of recipes. But abundant pickings of high-quality nuts are only possible if the tree escapes the devastating disease called "pecan scab." Caused by the fungus *Fusicladium effusum*, it is the most destructive disease of pecan in the southeastern United States. When scab is severe, most often when rainfall is above average, nut size is reduced, and total crop loss might occur.

Scientists at the Southeastern Fruit and Tree Nut Research Laboratory in Byron, Georgia, are working to help pecan growers mitigate the effect of pecan scab. Research leader Bruce Wood, plant pathologists Clive Bock and Michael Hotchkiss, and entomologist Ted Cottrell are using various approaches to reduce the impact of scab.

Their studies were described in a series of papers in the journals *HortScience*, *Plant Disease*, and *Crop Protection*.

Wood and his colleagues determined that timely foliar applications of nickel to tree canopies can improve tree resistance to the pecan scab pathogen. Nickel is toxic to the scab fungus, providing additional protection.

"We combined nickel as a nutritional supplement with fungicides and applied them as air-blast sprays to commercial orchards," says Wood. "On the cultivar Desirable, the reduction in scab severity due to nickel varied from 6 to 52 percent. Fruit weight and kernel filling also increased, apparently from improved disease control."

MIKE HOTCHKISS (D2911-1)

Healthy pecan fruits. Foliar applications of nickel may protect pecans from the fungus that causes scab.

Bock and colleagues found that phosphite controlled pecan scab on both foliage and fruit early in the growing season. It also reduced disease on mature fruit, but not as well as an industry standard fungicide, triphenyltin hydroxide. However, scab on fruit late in the season is cosmetic and was previously shown by ARS scientists to have no effect on nut quality or yield.

"In our field tests, phosphite was directly toxic to the pecan scab fungus at concentrations similar to those in the lab," says Bock. "Phosphite provides an alternative chemistry for growers to consider. This is particularly useful because the scab fungus has developed resistance to some fungicides currently used for control."

Bock and his colleagues also studied whether fungicides applied from ground-based sprayers are providing adequate scab control in mature pecan trees, which can be 60 to 80 feet tall. They determined that, in pecan trees that did not receive fungicide, the disease was most severe in the lower canopy and least severe at the top of the tree. But in trees that did receive fungicide, disease was reduced only up to a height of 40 feet; above that, there appeared to be no effect of fungicide on disease severity, compared to the nontreated trees.

"There was a consistent reduction in scab severity on foliage and on immature fruit through August due to fungicide treatments below 40 feet," says Bock. "Where tall pecan trees preclude effective ground-based spray coverage, aerial application might be an option to reduce the severity of scab in the upper canopy. The efficacy of this option is currently being investigated."—By **Sharon Durham,** ARS.

*This research is part of Plant Diseases (#303) and Crop Protection and Quarantine (#304), two ARS national programs described at www.nps.ars.usda.gov.*

*To reach scientists mentioned in this article, contact Sharon Durham, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5128; (301) 504-1611, sharon.durham@ars.usda.gov.*

CLIVE BOCK (D2910-1)

Pecan fruit showing symptoms of pecan scab. The black lesions are diseased areas where spores of the scab fungus are produced.

# Fire Ant Venom Compounds May Be Useful as a Fungicide

**Red imported fire ants are named for the firelike burn of their sting.** Now, the same venom that packs such a painful wallop may actually do some good for a change.

Studies by scientists at the Agricultural Research Service's Biological Control of Pests Research Unit in Stoneville, Mississippi, have shown that certain alkaloid compounds in the venom—namely, piperideines and piperidines—can hinder growth of *Pythium ultimum*, a top crop pathogen worldwide.

Chemical controls, delayed plantings, and crop rotation are among methods now used against *P. ultimum*, which causes damping-off diseases that decay the seed or seedlings of vegetable, horticultural, and cucurbit crops. Despite such measures, damping-off remains a costly problem, and new approaches are needed, notes Xixuan Jin, an ARS microbiologist. He coinvestigated the potential application of fire ant venom in the management of soilborne plant pathogens with ARS entomologist Jian Chen and Shezeng Li of the Institute of Plant Protection in Baoding, China.

Research groups have studied the insecticidal and antibiotic properties of fire ant venom since the 1950s, including against crop pests such as fruit flies and boll weevils, and bacteria such as *Escherichia coli*. However, the Stoneville team is the first group not only to identify piperideine alkaloids, but also to demonstrate the properties of both piperideines *and* piperidines against soilborne plant-pathogenic *P. ultimum*.

The team demonstrated this on two fronts—in petri dish experiments using *P. ultimum* colonies and in greenhouse trials with container-grown cucumber seedlings. In the first experiments, the team exposed the pathogen's threadlike growth form, called "mycelium," to various piperideine or piperidine concentrations and monitored the effect on the colony size of *P. ultimum*.

RICHARD NOWITZ (K3637-5)

Compounds in the venom of the red imported fire ant could prove promising for managing plant diseases caused by *Pythium ultimum.*

The pathogen's sporangia, or spore-forming structures, were also exposed to the two alkaloids. In the greenhouse trials, the alkaloids were mixed separately in a solution and applied to cucumber seedlings as a drench treatment.

The results, reported in 2012 *Pest Management Science*, include significant reductions in growth and germination of *P. ultimum* mycelium. Both alkaloids performed equally well and retained their activity against *P. ultimum* for up to 12 weeks when stored at room temperature.

STEPHEN AUSMUS (K11617-1)

In Stoneville, Mississippi, entomologist Jian Chen works with red imported fire ants.

In petri dish experiments, more than 90 percent of sporangia failed to germinate when exposed to piperideine or piperidine concentrations of 51.2 micrograms per milliliter of solution. Higher amounts (56.5 and 565.2 micrograms/milliliter) were effective in greenhouse experiments. Additionally, cucumber seedlings treated with the alkaloids grew taller than untreated seedlings.

Despite the alkaloids' promise in managing damping-off diseases caused by *P. ultimum*, "Further studies on disease-control mechanisms and phytotoxicity are needed," says Xixuan.

In their experiments, the researchers used sophisticated extraction techniques to obtain purified amounts of piperdeine and piperidine from the venom glands of both red and black imported fire ants. Producing commercial amounts would require considerable scale-up, even though these biting, stinging pests are a plentiful "resource," infesting over 320 million acres in the South, where they've become a dominant species as well as in other states and Puerto Rico.

One approach may arise from the work of a University of Mississippi team, which has succeeded in creating synthetic versions, or "analogs," that mimic piperideines identified by the Stoneville group. Two of seven synthesized analogs, even when used at especially low concentrations, were effective at inhibiting several cultured human fungal pathogens, raising the prospects for the analogs' use as novel antifungal agents.—By **Jan Suszkiw,** ARS.

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

*Jian Chen and Xixuan Jin are in the USDA-ARS Biological Control of Pests Research Unit, 59 Lee Rd., Stoneville, MS 38776-0067; (662) 686-3066 [Chen], (662) 686-3720 [Jin], jian.chen@ars.usda.gov, xixuan.jin@ars.usda.gov.*

# Possible Links Between Soil Microbial Communities and Stroke Risk

**"A big part of our Agricultural Research Service culture is cross-talking with outside researchers," says ARS soil and water scientist Patrick Hunt. "Partnerships are what we do."**

So one day in 2011, Hunt called Medical University of South Carolina professor Daniel Lackland to discuss a paper Lackland had published about stroke risk in the state. South Carolina is part of the U.S. "Stroke Belt," where residents have a significantly higher incidence of stroke than the rest of the U.S. population. South Carolina counties with the highest rates of stroke—between 89 and 115 cases per 100,000 residents—are found within the Southern Coastal Plain, which "buckles" the Stroke Belt (see map).

Lackland had determined that South Carolina stroke victims in the state's Pee Dee region—located in the Stroke Belt "buckle"—were on average 10 years younger than stroke victims outside the Belt. His studies also indicated that individuals born in the Stroke Belt have an increased risk of stroke in their lifetime, a risk that remained even if they moved away from the Stroke Belt later. He had identified some very intriguing trends, but he did not fully understand what might be driving those trends.

"Over the past 30 years, I've been involved with research projects focused on racial and geographical disparities in stroke risk," Lackland says. "One of the major objectives of these investigations is to identify factors associated with the high stroke risk in this part of the country. Unhealthy lifestyle and the Southern diet are often proposed as reasons for the disparities. But similar high-fat and high-carbohydrate diets are seen in other parts of the country. So we must study other factors."

### Mapping the Odds

As a result of their initial talks, Lackland and Hunt began to collaborate with ARS microbiologist Tom Ducey and ARS soil scientist Jarrod Miller to support Lackland's epidemiological research with some environmental expertise. The three ARS scientists work at the ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina. Retired ARS soil scientist Warren Busscher, who worked at the Florence laboratory, also contributed to the project.

"Lackland's results indicated that stroke risk was not just related to diet or lifestyle choices," says Ducey. "They strongly suggested that an environmental factor was at work as well." So the team designed a study to determine whether certain soil characteristics in the region's sandy Carolina Coastal Plain soils could serve as risk markers for stroke and whether those characteristics could be pinpointed by geostatistical analysis.

"Looking at soil patterns and stroke patterns was a reasonable place to start," Lackland says. "In addition, we were able to assess the links using data that were already available, which was a very efficient use of existing resources."

To identify associations between stroke risk and soil characteristics, the researchers obtained 10 years of South Carolina inpatient and emergency room discharge data that listed stroke as a primary diagnosis and compared it to state soil data from the USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic database. The soil characteristics evaluated in the research included cation exchange capacity; hydrologic soil group; sand, silt, clay, and organic matter content; saturated hydraulic conductivity; depth to water table; septic suitability; soil surface acidity; drainage class; and flooding frequency.

In their initial analysis, the team found that stroke rates were significantly correlated with depth to water table and soil drainage class. Stroke rates were higher in counties where soil depth to water table was between 20 and 59 inches, which is often the case for shallow water tables in the Coastal Plain. (Soils with water tables less than 20 inches deep are usually found in flood-prone areas near streams, rivers, or wetlands—sites that are generally unsuitable for residential use.) Links between stroke rate and soil drainage were also significant: Well-drained soils had a negative correlation (fewer strokes), while poorly drained soils were positively correlated (more strokes).

"These links," Ducey comments, "give the scientific community a good foundation for developing further studies of the geographic distribution of stroke risk."

The team then focused their investigation on soil characteristics in South Carolina counties with the 10 highest stroke rates—all within the Coastal Plain—and those with the 10 lowest stroke rates, all in the Blue Ridge/Piedmont region. Findings from this part of the study indicated that soils with a depth to water table from 20 to 59 inches continued to be strongly correlated with stroke rate, while soils with a depth to water table of more than 79 inches were negatively correlated.

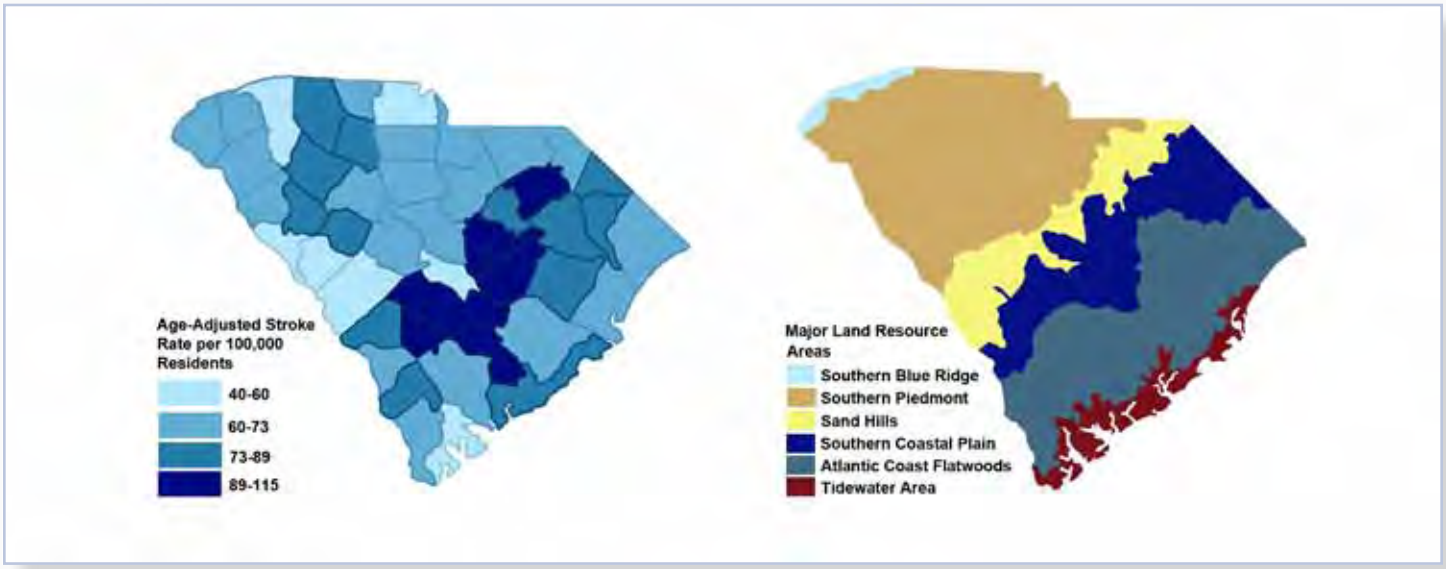
Moderately well-drained to poorly drained soils were also positively correlated with stroke rate, while well-drained soils had a negative correlation. In addition, strongly acidic soils had a strong positive correlation with stroke rate.

In short, soil characteristics with strong positive correlations to stroke risk were all typical of Coastal Plain soils.

"I had a suspicion this is what we would find," Ducey said. "It was clear that the Stroke Belt map aligned with the Coastal Plains soils map and that the distribution of stroke rates didn't show any real links to the location of the hilly and rocky Piedmont soils."

"In general, soil maps show the location of very broad categories of soil characteristics," Miller adds. "So given the broad nature of the data, it was very interesting that we found any correlations at all between soil characteristics and stroke risk."

THOMAS DUCEY (D2939-1)




Scientists from ARS and the Medical University of South Carolina compared South Carolina stroke data to soil characteristics. They found links between the counties that have the highest stroke risk (left) and the areas that have soil characteristics typical of the Southern Coastal Plain (right).

**Risky Terrain**

There are two classic factors that affect the makeup of soil microbial communities: soil moisture and soil acidity. A different diversity of organisms can be found in moist, acidic soils than in drier, more alkaline soils. Based on this, the researchers hypothesize that Coastal Plain residents might be at higher risk for stroke because of the prevalence—or perhaps lack—of specific microbes in the region's moist, acidic soils. The scientists all strongly concur that this hypothesis will need much more testing and validation before it can be confirmed.

Discussions about how these soil microbes could specifically affect human health, including stroke risk, are just beginning. But researchers in a range of disciplines are now exploring how health and disease can be affected by the huge numbers of bacteria, viruses, and other microbes that live in the human body. This impressive assortment of microbes, which is called a "microbiome," varies from person to person, depending on what each person is exposed to—and when the exposure occurs—throughout a lifetime.

Based on their findings, the South Carolina scientists hypothesize that an early-life exposure to the specific microbial mix in Coastal Plain soils might affect microbiome development in a way that leaves some individuals more vulnerable to cardiovascular events like stroke. Although this effect would vary from person to person, depending on other environmental and genetic factors, it might help explain the puzzling regional patterns of stroke risk.

"I'm not totally surprised by these results, but I was surprised by the magnitude of correlation between soil characteristics and stroke risk," says Lackland. "This is a preliminary study, and it needs additional follow-up and confirmation. But if other studies have similar results, it could provide new information about risk factors for stroke and allow us to develop new interventions that could help reduce stroke rates in this region."

Because of data constraints, the study was restricted to South Carolina. But the Southern Coastal Plain extends from Virginia through the Carolinas, Georgia, and the Florida panhandle, as well as into Alabama, Mississippi, Louisiana, and Kentucky. All these regions are recognized as part of the Stroke Belt.

NRCS currently doesn't collect data on the distribution of soil microbial populations, so there are no clues about which microbes might be the environmental link between Coastal Plains soils and stroke risk. Ducey contends that information about soil microbe communities could be acquired using new biotech instruments in laboratories such as the ARS lab in Florence. In this way, data generated by ARS to benefit agriculture would benefit epidemiology as well.

"A microbial map of South Carolina could be developed from approximately 300 to 400 soil samples. This could allow microbial populations to be looked at in future studies," Ducey says.

"This study helps broaden the thinking about the different factors that might be involved in this serious health problem," says Hunt. "It shows how sharing theories and technologies across scientific disciplines can result in valuable outcomes."

"We've known about the geographical and racial disparities in stroke risk for five decades," Lackland agrees. "We've identified many of the factors, including high blood pressure and diabetes, that increase stroke risk, but we still don't have a comprehensive answer for why some parts of the population suffer excessive stroke rates. This work could be an important step in that direction."

The team published its findings in 2012 in the *Journal of Environmental Science and Health*.—By **Ann Perry,** ARS.

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

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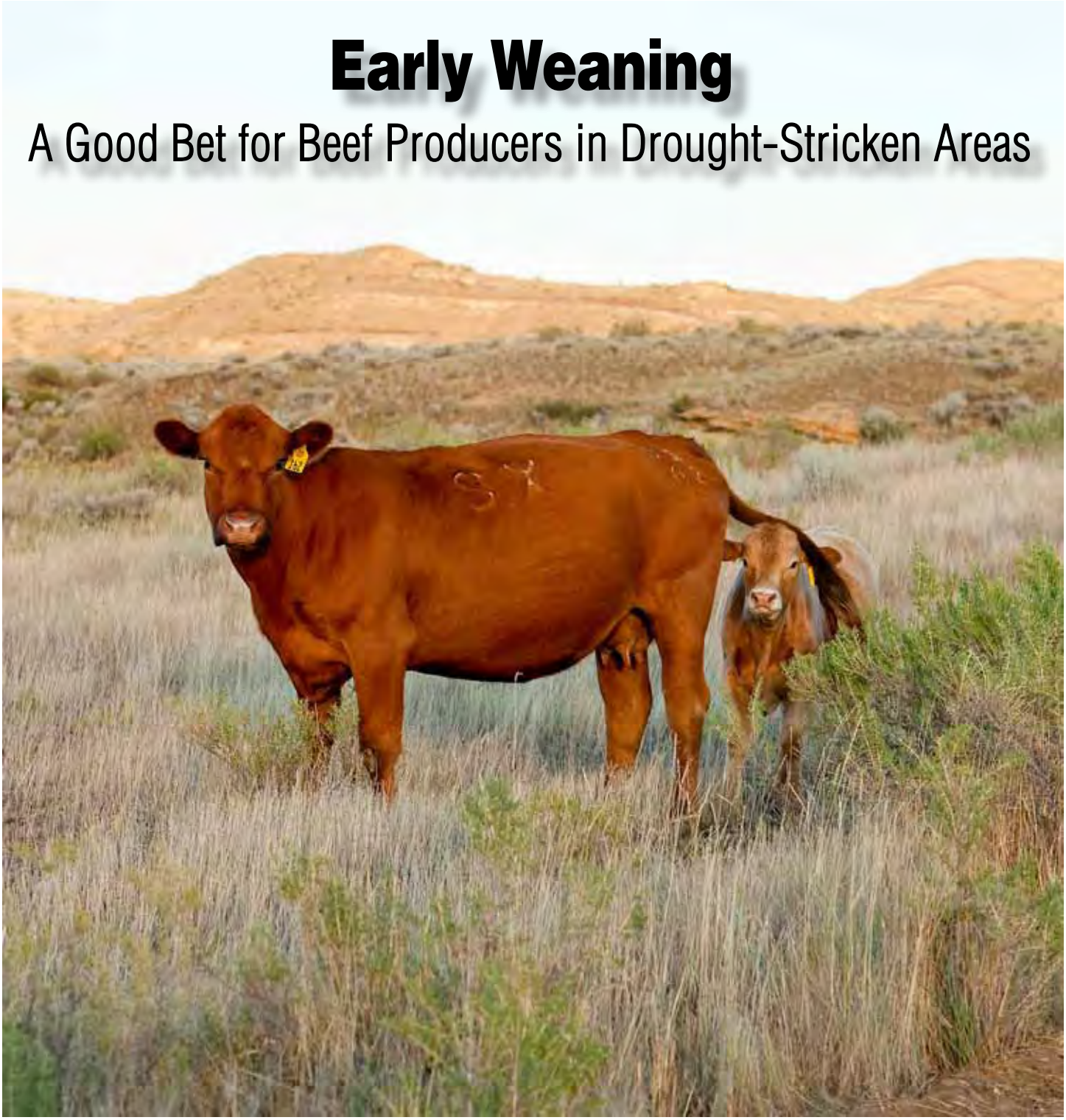
STEPHEN AUSMUS (D2038-39)

# Early Weaning

## A Good Bet for Beef Producers in Drought-Stricken Areas



Beef producers, when hit with drought, have limited forage for cows to eat. The result is usually reduced calf growth and reduced weights at weaning. ARS scientists confirmed that early weaning is a beneficial production alternative for beef producers when forage is limited.

At the beginning of 2013, cattle ranchers in the Northern Plains were among U.S. agricultural producers still feeling the lingering effects of the sweltering 2012 drought, the worst in half a century.

Beef cow numbers were at the lowest in 50 years as U.S. beef producers—severely affected by extended drought—tried to recover from some of the driest months on record.

Across the Northern and Southern Plains, beef producers hit the hardest by drought are threatened by limited forage resources for cows, which restricts calf growth, resulting in lighter calf weaning weights. In addition, drought can decrease cow body weight and condition and weaken immune functions that may affect overall health and reproductive performance.

For decades, scientists at the Agricultural Research Service's Fort Keogh Livestock

and Range Research Laboratory (LARRL) in Miles City, Montana, have studied management options that minimize the effects of severe drought on rangeland livestock production. Recently, LARRL animal scientists Richard Waterman, a rangeland nutritionist, and Thomas Geary, a reproductive physiologist, teamed with local ranchers and collaborators at Montana State University (MSU) and the American Simmental Association in Bozeman, Montana, to evaluate early weaning of beef calves and its impact on cow, heifer, and steer performance.

"When a calf is weaned early, all nutrients that normally go to milk production for the calf can be retained by the mother—helping to increase or sustain her body weight and condition," Waterman says. "And proper handling of early-weaned calves can result in greater weight gain than if they had remained with their mothers, especially during drought."

### Tallying the Benefits

Scientists confirmed that weaning a calf earlier than normal potentially offers a beneficial production alternative for beef producers when forage is limited.

"With the calf removed, the cow needs less forage to address her needs, which is especially important during drought," Waterman says.

"Another issue with drought is the inability to grow enough summer and winter forage for cattle," says rancher and collaborator Dean Peterson, who volunteered his cow/calf herd in Judith Gap, Montana, for the project. "We used to run 500 cows, but now we run 400, because it's about maximizing the efficiency of the forage. We suffered an initial loss of income, but we're doing a better job at taking care of the land and cattle, and our operation is sustainable for the long term."

Research was conducted using calves from both Judith Gap and LARRL. Some calves were weaned early, at 80 days of age, while others were weaned at the more traditional age of 215 days. Cows that weaned a calf early weighed more and were in better body condition at the start of winter. Consequently, the amount of harvested feedstuffs required for cows to maintain satisfactory body weights and condition throughout winter was reduced.

"We learned a lot," Peterson says. "The research confirmed that early weaning is profitable. If you wean calves early, you have fewer problems and can better control the production environment."

"Early weaning during severe droughts will reduce economic losses that would occur when selling lightweight calves," Waterman says. "In order to achieve an economic benefit, a 20-percent increase in reproductive performance in the cow herd would need to be realized, because early-weaned calves must go on feed much sooner."

Outcomes of the research also demonstrated that early weaning increases the probability of heifers becoming pregnant on time in the following breeding season, Waterman says.

"The nice response was in body weight, especially with those 2-year-olds nursing for the first time," he says. "It takes a cow 5 years to reach her mature body weight. When young cows have their calves removed early, the demands of lactation cease—allowing the cow to focus her resources on body condition and growth. If a cow goes into winter in better condition, maintains that condition, and calves with better condition the next year, she will be much more likely to remain in the herd until maturity."

The objective is to preserve body condition of the cow at a time when forages are limited, says John Paterson, a former MSU animal science professor and Extension Service beef cattle specialist. "We don't want cows to get thin or pull body condition down, because they're lactating, which requires a lot of feed. The way you save that feed is to stop lactation by getting the calf weaned earlier."

### Steering in the Right Direction

Additional findings showed that early-weaned steers reached maturity sooner than traditionally weaned steers when weight gain, feedlot performance, and carcass traits were measured. Steers had a higher rate of growth between the time of early weaning and the time of normal weaning.

Early-weaned steers typically had poorer USDA yield grades, revealing the importance of identifying them before they enter the feedlot, Waterman says. While producers who market cattle using a quality grid will benefit from having a higher quality carcass going into market, research indicates that management of early-weaned calves can directly affect how they are graded at harvest.

"Carcasses of early-weaned steers may be too fat and receive less-desirable USDA yield grades compared to those of traditionally weaned calves of similar genetics and age when harvested together," Waterman says. "If early-weaned steers are identified before entering the feedlot and harvested at an earlier age, producers have the opportunity to market them at more desirable yield grades with increased quality premiums for those carcasses."

Partnering with the University of Illinois, scientists confirmed this strategy by using ultrasound to measure carcass characteristics. Early-weaned steers were then harvested at a younger age than traditionally weaned animals to maximize their carcass value.

"This research involved cattle that were on Montana ranches, so it was the real deal," Paterson says. "When you wean earlier and get those cattle into the feedlot, the quality and yield are very nice. A lot of ranchers have figured that out, because it's an economic issue as much as anything else."

Peterson is among those ranchers. "We went far enough into the study to get the benefits on the other end," he says. "We had better cattle with early weaning because it helped our quality too. And because we retained ownership of all our steers and heifers until slaughter, we were able to realize those premiums. We had better carcasses when we weaned earlier."—**Sandra Avant,** ARS.

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

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PEGGY GREB (D863-25)

# Fungal Foam Tested Against Avocado Threat

A foam originally developed by ARS as a way to pump fungal spores into the galleries of Formosan subterranean termites may be useful against ambrosia beetles that attack avocado trees.

**Avocados aren't just nutritional powerhouses;** they're also the chief ingredient in such party favorites as guacamole dip.

More than 99 percent of the nation's $322 million avocado crop is grown in south Florida and southern California (less than 1 percent is produced in Hawaii), which makes recent infestations of groves there by invasive, wood-boring ambrosia beetles so alarming. A host of counter strategies are in the works, including a biobased foam originally developed by Agricultural Research Service scientists for use against Formosan subterranean termites.

In Miami-Dade County, Florida, avocado growers are contending with *Xyleborus glabratus*, the redbay ambrosia beetle. In California, particularly Los Angeles County, the fight is against a different ambrosia beetle species—the polyphagous shot hole borer, *Euwallacea* sp.

Both tunnel into the sapwood of avocado trees, inoculating them with pathogenic fungi in the process. Redbay ambrosia beetles specifically attack members of the Laurel tree family (which includes native tree species and avocado). The shot hole borer, however, has a host range of more than 100 different tree species in 59 different families.

The culprits are fungal pathogens that the beetles carry with them into trees and "farm" as food. *Raffaelea lauricola*, the fungus spread by redbay ambrosia beetles, causes laurel wilt disease, which is lethal to avocado and other trees. The *Fusarium* species associated with the borer causes *Fusarium* dieback, which is lethal to some but not all of the woody plants the insect attacks.

Spraying avocado groves with insecticides to kill the beetles before they infect trees with the fungi may not be an effective disease-management approach, notes Alejandro Rooney, who leads ARS's Crop Bioprotection Research Unit at the National Center for Agricultural Utilization Research in Peoria, Illinois.

To fight the harmful fungi, Rooney and colleagues are investigating the potential use of beneficial fungi to target the ambrosia beetles. These include entomopathogenic (insect-infecting) species of *Metarhizium*, *Isaria*, and *Beauvaria*. Early evidence has been promising, notes Rooney, whose team is collaborating with Jorge Peña, Daniel Carrillo, and Jonathan Crane—all with the University of Florida at Homestead—and Akif Eskalen and Richard Stouthamer at the University of California-Riverside.

Using DNA markers, ARS chemist Chris Dunlap devised special tests called "bioassays," which enabled the team to genetically confirm the microbe's ability to infect and kill the beetles—in addition to visual proof in the form of moldy growth on the pests' bodies.

"Our research has shown that three separate strains of the fungi are fatal to the insects, with fungal-induced beetle mortality greater than 95 percent," Dunlap reports.

STEPHEN AUSMUS (D2634-12)

Female redbay ambrosia beetle, *Xyleborus glabratus* (about 2 mm long).

Repeating this success inside the trunks of avocado trees is the next important step in the team's investigations, and that's where the biobased foam could figure prominently.

Dunlap and ARS colleagues Mark Jackson, Robert Behle, and Maureen Wright originally developed the foam as a way to pump fungal spores deep into the galleries of Formosan subterranean termites, which can nest inside trees. The research team is evaluating the foam's potential against ambrosia beetles in orchard-scale trials with avocado trees.

Polyphagous shot hole borers stimulate a host response in avocado that includes gumming and a white residue around holes the insect has formed. "This gives away their position, and we can spray the foam directly there at the sites of infestation," Dunlap says.

That's not the case with redbay ambrosia beetles, which makes locating them more difficult. For this reason, "We'll probably use a combination of spraying the entomopathogenic fungi on trees and on an avocado mulch, which we know the beetles are attracted to."

Continued field research will be key to determining the effectiveness of this biobased approach to controlling ambrosia beetles. But if successful, it could ultimately help to safeguard an important domestic crop.—By **Jan Suszkiw,** ARS.

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

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*The Agricultural Research Service has about 100 labs all over the country.*

## Locations Featured in This Magazine Issue


*Locations listed west to east.*

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

### Albany, California
9 research units ■ 241 employees

### San Joaquin Valley Agricultural Sciences Center, Parlier, California
3 research units ■ 125 employees

### Northwest Watershed Research Center, Boise, Idaho
1 research unit ■ 18 employees

### Tucson, Arizona
2 research units ■ 54 employees

### U.S. Sheep Experiment Station, Dubois, Idaho
1 research unit ■ 10 employees

### Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana
1 research unit ■ 25 employees

### Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska
6 research units ■ 117 employees

### Grazinglands Research Laboratory, El Reno, Oklahoma
2 research units ■ 43 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 ■ 260 employees

### Southeastern Fruit and Tree Nut Research Laboratory, Byron, Georgia
1 research unit ■ 47 employees

### Tifton, Georgia
3 research units ■ 103 employees

### Coastal Plains Soil, Water, and Plant Research Center, Florence, South Carolina
1 research unit ■ 38 employees

### U.S. Horticultural Research Laboratory, Fort Pierce, Florida
4 research units ■ 148 employees

### Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, Maryland
30 research units ■ 707 employees

### New England Plant, Soil, and Water Research Laboratory, Orono, Maine
1 research unit ■ 10 employees

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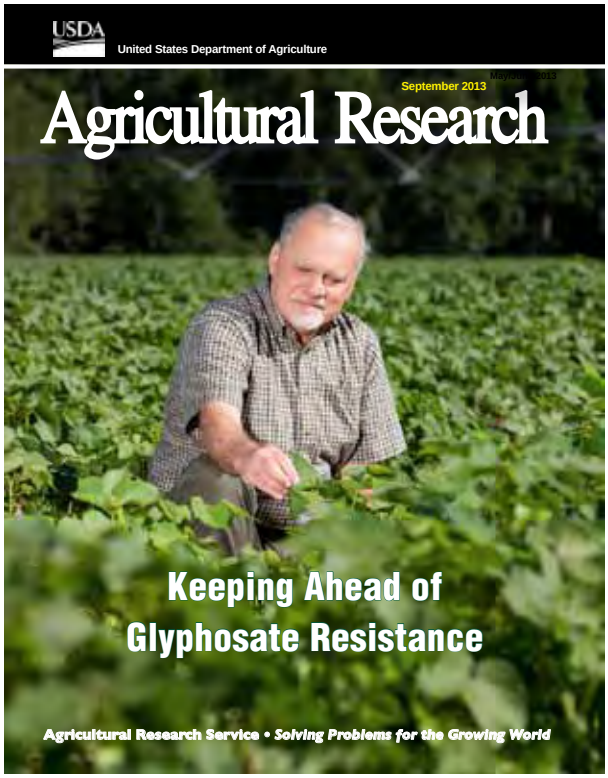
PEGGY GREB (D2957-1)




## Inside Next Online Issue

## Spotlight On ...

### USDA Plant Hardiness Zone Map


The 2012 USDA Plant Hardiness Zone Map is the standard by which gardeners and growers can determine which plants are most likely to thrive at a location. The map is based on the average annual minimum winter temperature, divided into 10˚F zones.