

Agricultural Research

Biomass for Biofuels

A Regional Approach

pages

2, 4-15



FORUM

Biofuels: No Single Answer, Many Possibilities

Biofuels research has been part of the Agricultural Research Service's core mission for more than 40 years.

ARS has long been a leader in biofuels research, with such successes as helping to perfect the cold tolerance of biodiesel, finding that briefly exposing corn grain to anhydrous ammonia can reduce costs of fuel ethanol production, and validating the economic and environmental benefits of switchgrass as a nonfood crop for biofuels.

The goal today is to help industry accelerate progress towards establishing commercial biofuel supply chains nationwide, beyond ethanol from corn grain towards solutions that will help commercial airlines, the U.S. Navy, and others meet their renewable-fuel-use goals in a sustainable way. Meeting these goals requires that ARS help develop new dedicated bioenergy crops, improve production and harvest systems, and enhance industrial biomass conversion processes so that costs can be lowered throughout the supply chain, making the cost of biofuels competitive with that of petroleum-based fuels.

But the commercial growth and long-term viability of renewable fuels in this country are impeded by a number of technical and economic barriers. ARS has unique strengths and capabilities to address many of them.

Ensuring that dependable, abundant, and affordable feedstocks are available is critical for developing a strong renewable-fuels industry in the United States. Farmers need to know that the biofuel crops they produce will have a profitable market, while biorefiners need assurance that if they build a plant, the biomass they need will be readily available and priced so the fuels they produce can compete with petroleum-based fuels. Everybody in the biofuels supply chain needs to be able to make a profit.

To support the development of complete supply chains, ARS research programs are encouraging collaborations among scientists across a wide variety of disciplines, commercial partners who will put the research results to use, and users who will purchase the biofuels.

For example, ARS scientists and a commercial sugar company in Hawaii are working together to determine the most economical options for expanding renewable energy production on Maui. With support from the U.S. Navy, the researchers are helping to determine the best options for producing energy cane to make fuels for the Navy and electricity for the island.

Working with University of Hawaii researchers, the team is determining how to fit energy crop production into plantation-management plans. The research is building tools that can not only be used in Hawaii but elsewhere in the Pacific Basin, and also on the mainland. Given the diversity of growing and production environments across the country, ARS recognizes there won't be just one answer to all of the questions about how to sustainably achieve biofuel success.

So ARS is focusing on finding region-based answers, knowing that no one region will be able to produce all of the feedstocks needed to meet our national biofuel and other renewable-energy goals. Developing bioenergy crops that work for different growing regions will also provide opportunities for many rural communities to participate and help make production of biofuels a nationwide endeavor.

Reinforcing this localized approach was the establishment of five USDA Regional Biomass Research Centers, announced by U.S. Department of Agriculture Secretary Tom Vilsack in 2010. The purpose of the centers is to provide a coordinated research focus designed to develop relatively short-term deliverables to help accelerate the

establishment of a commercial biomass feedstocks industry.

Together, the Regional Biomass Research Centers embody a nationwide network of USDA scientists and facilities managed by ARS and USDA Forest Service Research and Development. The centers are helping to lead a national research effort to develop sustainable biomass production systems, superior performing feedstocks, and value-added coproducts to help industry establish commercial biofuel supply chains.

ARS is also developing partnerships with other federal agencies, universities, states, and private industry. The centers are targeting partnerships to include 1890 land-grant, Tribal Nations, and Hispanic-serving institutions. For example, ARS researchers are working with the Colville Confederated Tribes to design a way to fit winter oilseed production into wheat crop rotations on tribal and neighboring lands in the Pacific Northwest. The seed oil will be extracted locally and used to make biodiesel for the tribe's school buses and logging trucks.

ARS has also formed a partnership with the U.S. Federal Aviation Administration to help air-transportation interests and other decisionmakers develop the best plans for producing biofuels to benefit commercial aviation. This work will ultimately help the aviation industry stabilize fuel costs and reduce greenhouse gas emissions.

In this issue of *Agricultural Research* magazine, you can read more about the USDA Regional Biomass Research Centers and how ARS research is making the future of bioenergy grow.

Jeffrey Steiner

ARS National Program Leader
Biomass Production Systems
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: **Tara Weaver-Missick** (301) 504-1663
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.

MARK EHLENFELDT (D2600-1)



Some blueberries begin to lose some flavor soon after they have been picked. But this recently released ARS variety holds onto that flavor so it will be delicious when it makes its way to consumers. [Story begins on page 16.](#)

-
- 4** ARS and the Regional Biomass Research Centers
 - 7** Biofuel Prospects With Prairie Perennials
 - 10** Finding the Right Biofuels for the Southeast: A Range of Alternatives
 - 14** ARS Researchers Flying Higher With New Jet Fuels
 - 16** Pink Lemonade, Razz, and More! Wonderful Blueberries From ARS to You
 - 18** Making Fruit Flies More Macho for Sterile Insect Releases
 - 20** Banking on Plants as Storehouses
 - 22** A Cautionary Note About Copper Footbaths for Dairy Cows
 - 23** Locations Featured in This Magazine Issue
-

Cover: In research plots in Shellman, Georgia, geneticist Bill Anderson measures the height of napiergrass, one of the prime candidates for biofuels production in the southeastern United States. Anderson and his team are working toward developing biomass crops for producing biofuels in this region of the country. [Story begins on page 10.](#) Photo by Peggy Greb. (D2603-1)

ARS and the Regional Biomass Research Centers

In 2010, U.S. Department of Agriculture Secretary Tom Vilsack created five Regional Biomass Research Centers to help make the most of existing USDA research resources. A commitment to research is necessary to help establish a successful bioenergy industry in different parts of the country through the development of dependable supplies of feedstocks for advanced biofuels production. A regional approach to feedstock production will help enable broad participation by many rural areas across the country in the emerging biofuels and biobased-products economy.

In particular, the regional biomass centers organize USDA's Agricultural Research Service and Forest Service bioenergy research into a structure that fosters collaboration among researchers along the complete bioenergy-production continuum.

The five USDA Regional Biomass Research Centers serve to complement and coordinate ARS and Forest Service research across the country to help accelerate the establishment of commercial, region-based biofuel supply chains based on agricultural and forestry-based feedstocks. The centers are networks of existing ARS and Forest Service facilities and scientists in locations across the country.

Northern-East Regional Center: This center is coordinated by the Forest Service Research and Development and focuses on

production of woody biomass for biofuels, with research directed at screening for superior traits; short-rotation woody crops; sustainable management systems, including forest health and conventional forest operations; life-cycle analysis; quantifying sustainable supply and demand; conversion of woody biomass to advanced fuels and coproducts; and design of biofuels and coproduct deployment.

Southeastern Regional Center:

The highest priority research need for the Southeastern region is the development of superior performing herbaceous feedstocks: energy cane; biomass sorghum, including sweet sorghum; other subtropical/tropical perennial grasses, such as napiergrass; and purpose-grown woody biomass. There is also a need to identify the best strategies to incorporate dedicated biomass crops into existing annual row crop, pasture, agroforestry, and forest-based systems, as well as to develop long-term strategies for using perennial energy grasses to meet the needs of emerging advanced-biofuel-producing facilities in the region.

Western Regional Center:

With the relatively low precipitation in much of the western United States, the Western Regional Center's feedstock research focuses on the development of new industrial oilseed crops. Oilseed crop research is conducted in conjunction with research at the Northwestern Regional

Center and includes genomic modifications to optimize fatty acid genes and breed new oilseed cultivars, characterizations of germplasm collections to identify new feedstock types, and population phenotyping. New cropping systems are needed that fit specific local and regional niches for available resources and economic development, especially under limited water availability. Woody biomass research efforts include management and use of invasive eastern red cedar, pinion pine, and western juniper to restore degraded rangelands; use of insect-, fire-, or disease-killed wood and areas at high risk of damage or loss; sustainable productivity and residue removal; economics of in-woods pyrolysis and biochar and assessment of ecological outcomes; and the logistics and costs of handling and transportation.

Northwestern Regional Center:

This center's oilseed crop efforts are coordinated with those of the Western Regional Center, with an emphasis on integrating expanded oilseed production and minimizing its impact on existing wheat-based production systems. The center is also focused on restoration of western rangelands through harvest and removal of invasive western juniper and pinion pine trees. The woody biomass emphasis is on wood utilization; poplar genomics, genetics, and short rotation management; forest resource supply and characterization; production

As part of its regional approach to developing bioenergy crops, ARS is working on ways to increase the energy potential of sugarcane, from improving its genetics to growing it sustainably under various management plans on plantations from Louisiana to Hawaii.



RICHARD BAIN, NREL/DOE (D2633-1)



ARS scientists have been studying switchgrass for decades to determine if it is a viable feedstock for bioenergy production.

standards for sustainable forest management systems; alternative energy policy evaluation; and economic feasibility of feedstock supply alternatives.

Central-East Regional Center: For this center, the main research focus is on the development of perennial grasses and biomass sorghum, along with significant coordination of research on corn grain ethanol and corn stover cellulosic biomass. Emphasis is on integrating dedicated feedstock production into central-eastern agricultural production systems to enhance water and air quality and to minimize the adverse affects of bioenergy on existing agricultural markets.

As with all of the other centers, there is an emphasis on the need to increase system efficiency through introduction of nitrogen-fixing plants such as alfalfa and other legumes. Integration of perennial grass feedstocks into these systems may be a way to help reduce nutrient escape

from fields to surface and ground waters and to reduce greenhouse gas emissions and increase carbon sequestration.

Geneticist Ken Vogel at the ARS Grain, Forage, and Bioenergy Research Unit in Lincoln, Nebraska, who also serves as coordinator for the Central-East Regional Center, is no stranger to bioenergy research.

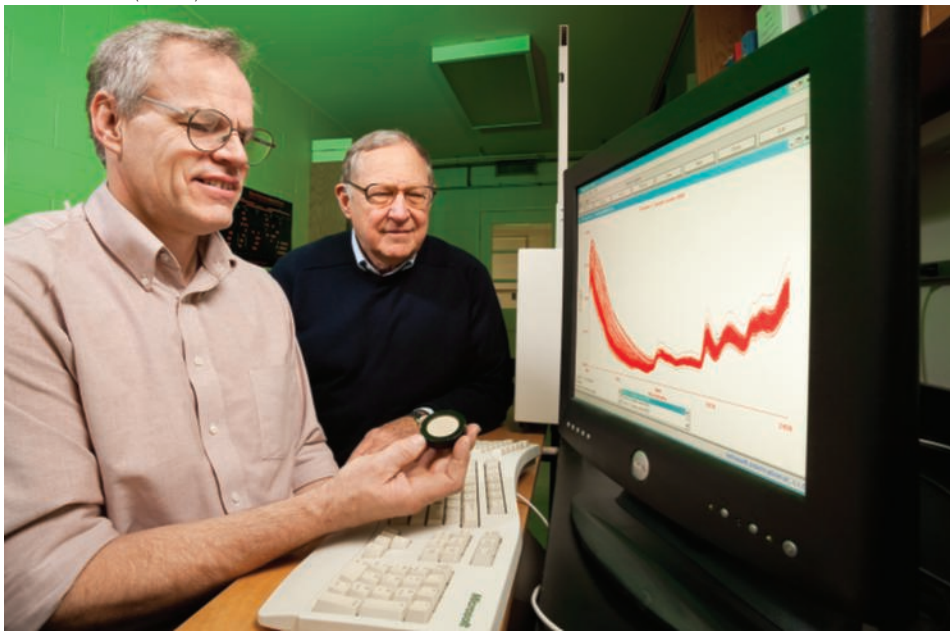
When Vogel started his switchgrass research in the 1970s, he focused on improving both the quality of livestock forages and the establishment of forages on pastures. But by 1990, he began developing switchgrass as a biomass energy crop, sparked in part by interest and support from the U.S. Department of Energy (DOE).

“Switchgrass was already being grown on land that was part of the Conservation Reserve Program [CRP], and farmers were receiving CRP payments, but the land was not producing any marketable products and new revenue,” says Vogel. “I wanted to see if we could grow a crop on CRP land that

would generate income and address U.S. energy needs.”

Vogel worked with Oak Ridge National Laboratory staff on a series of interagency agreements that provided funding for developing switchgrass into a biomass energy crop for the Central Great Plains and the Midwest. After the initial DOE funding ended in 2002, USDA continued its support of the research.

In the initial studies, Vogel and his colleagues established a test plot in each of three states—Indiana, Iowa, and Nebraska—to evaluate almost all the available cultivars and elite strains of switchgrass. Their results showed that it was possible to develop switchgrass cultivars with high biomass yields that could be successfully grown across a broad geographic region. They also found that existing switchgrass cultivars developed for forage had the potential to produce biomass that could yield more than 500 gallons of ethanol per acre.



Vogel's team evaluated switchgrass germplasm from Midwest prairies and identified cultivars and germplasm with the most promising traits for bioenergy. Then they used that information to conduct genetic studies to obtain information for improving breeding methods and developing hybrid cultivars, including the first molecular genetic studies on switchgrass.

Results from a later, 5-year, multi-state, on-farm study demonstrated that the amount of energy contained in cellulosic ethanol produced from switchgrass was five times greater than the amount of energy needed to grow, harvest, and process the crop into cellulosic ethanol. In addition, the greenhouse gas emissions from producing cellulosic ethanol from switchgrass were 94 percent lower than estimated greenhouse gas emissions from gasoline production. Assuming that switchgrass could be produced for \$50 per ton with a conversion efficiency of 80 to 90 gallons per ton of feedstock, Vogel's team estimated the farmgate production costs of cellulosic ethanol from switchgrass would be about \$0.55 to \$0.62 per gallon.

The Central-East team also developed the first near-infrared sensing (NIRS) method to measure 20 components in switchgrass—including cell wall sugars, soluble sugars, and lignin—that determine its potential value as a biofuel feedstock. Using NIRS, they tested switchgrass varieties and experimental lines and found significant differences in the amount of

ethanol that can be produced using current technologies and the amount that could be produced when technology is available for commercial-scale conversion of the plant sugars. This was calculated as actual and potential ethanol yield per ton and per acre. Results indicated that NIRS could estimate ethanol yields of switchgrass for about \$5 a sample; other methods cost anywhere from \$300 to \$2,000 per sample.

Other research at Lincoln has resulted in new information on how switchgrass and ethanol yields are affected by nitrogen fertility, harvest management, herbicide tolerance, stand establishment, and mycorrhizae—organisms in the soil that mediate

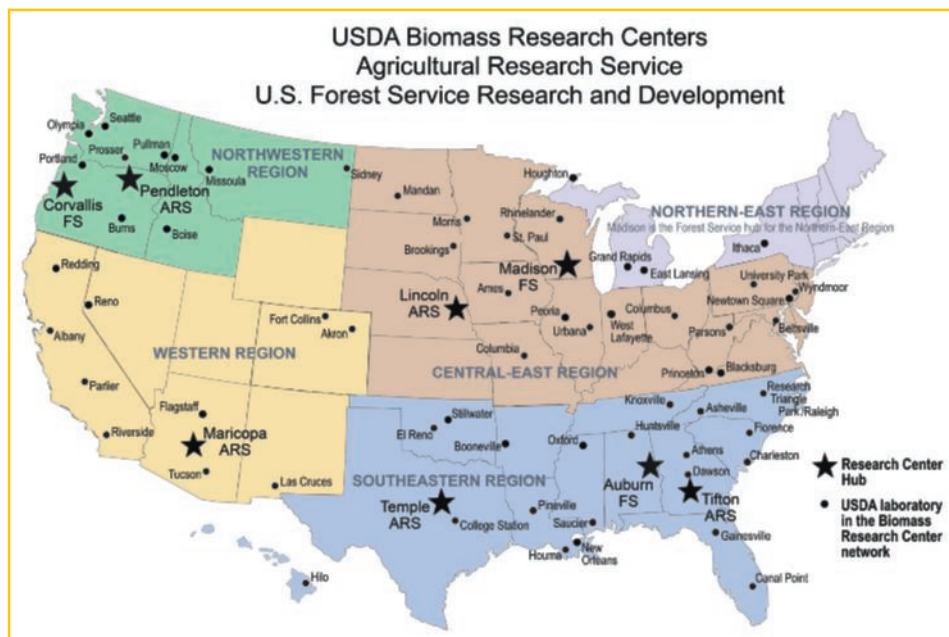
Geneticist Ken Vogel (background) and technician Steven Masterson examine near-infrared reflectance spectral profiles of switchgrass samples. Vogel worked with a team of ARS scientists to develop the first near-infrared sensing method for measuring 20 switchgrass components—including cell wall sugars, soluble sugars, and lignin—which can be used to determine the potential yield of cellulosic ethanol from switchgrass biofeedstock.

nutrient and water uptake. Vogel's team has used this information to develop a basic set of management guidelines and cultivars for large-scale production of switchgrass as a biomass energy crop in the Central Great Plains and the Midwest.

"It's satisfying to see lots of people working on switchgrass as a bioenergy crop," Vogel says. "We're getting much closer to the point where it will be a viable feedstock that helps meet our energy needs."—By **Ann Perry and J. Kim Kaplan, ARS.**

To reach scientists mentioned in this article, contact Ann Perry, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1628, ann.perry@ars.usda.gov. ✨

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



Biofuel Prospects With Prairie Perennials

Around 66 million years ago, a grasslike ancestor began to evolve into the plants eventually used to breed food crops like rice, corn, sorghum, and sugar cane. *Panicum virgatum*, or switchgrass, another plant descended from this ancient group, might someday become the energy equivalent of its food crop relatives—a biomass feedstock used to produce heat, light, and transportation fuels.

To further these prospects, the U.S. Department of Agriculture's National Institute of Food and Agriculture has awarded a 5-year, \$25 million grant to Iowa State University and its partners, including the Agricultural Research Service, to fund a project called "CenUSA." This study will investigate agricultural systems in the central United States for producing advanced transportation fuels from perennial grasses

grown on land that is either unsuitable or only marginally suitable for row crop production. The project researchers will also study approaches for improving the sustainability of existing cropping systems by incorporating perennial grasses into production systems as bioenergy crops, which will reduce nutrient runoff from fields, decrease erosion, and increase soil carbon sequestration.

Switchgrass, Big Bluestem, and More

Geneticist Ken Vogel, who works at ARS's Grain, Forage, and Bioenergy Research Unit in Lincoln, Nebraska, will lead CenUSA's "Germplasm to Harvest" group.

"We aim to develop crops that take only a single year to become established and can grow 50 percent of maximum yield in the first year of production—and 100 percent yield in the second," says Vogel. "We're also looking at other native grass feed-

stocks, like big bluestem and indiangrass. Part of our work will be planting field-scale demonstration plots of switchgrass and big bluestem to show farmers how to use these crops on their farms."

Geneticist Michael Casler, who works at ARS's U.S. Dairy Forage Research Center in Madison, Wisconsin, will be partnering in CenUSA's breeding and genetics research.

"Right now, it takes 5 years to select candidates, grow them out, cross with other genetic lines, develop and evaluate new types, and then get seed production," Casler says. "This generates around a 1-percent yield increase every year, but we want to accelerate that rate of yield progression."

Casler and colleagues will use new DNA markers to develop predictive equations for identifying traits that enhance yield. They will use these equations to breed and



Switchgrass (right) and no-till corn growing in Nebraska in a soil carbon sequestration study that has been in progress since 1998.

PEGGY GREB (D2611-1)

evaluate new experimental strains for yield and biofuel-conversion potential. These strains will be evaluated in field trials prior to release as cultivars for commercial use by the biofuels industry.

Casler is also helping to establish plots in the north-central states for studying switchgrass, big bluegrass, indiagrass, and prairie cordgrass. “In some places, big bluegrass has higher yields than switchgrass,” Casler says. “It is also more tolerant of mismanagement and less susceptible to invasive plants.”

Agronomist Rob Mitchell, who works with Vogel in Lincoln, will be coleading management-systems studies of bioenergy crops in a 14-field network across the central part of the country. “We’re using field trials to evaluate the switchgrass and other material that Vogel and Casler have already developed,” Mitchell says.

ARS and university scientists in Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Wisconsin will also evaluate the latest improved genetic materials and find the best ways to integrate new perennial bioenergy grasses into food-crop-production landscapes. Their work will include research on nitrogen cycling, carbon cycling, and greenhouse gas emissions—a key project component, since there is little information on greenhouse gas emissions for bioenergy crops. This data will be needed to develop biofuels that produce lower total emissions throughout the production-and-conversion cycle than the emissions associated with petroleum-based fuels.

The researchers will monitor water use by these crops and develop ways to optimize water-use efficiency, because water availability could be the single most limiting factor in U.S. biomass production. They will also compare the production inputs needed for the experimental biomass crops to those needed for corn.

“This will let us compare the production and economic benefits and costs of different bioenergy crops to those of other production systems,” Mitchell says.

Mitchell’s team will assess the net energy balance for different biomass systems, including yields, agricultural inputs, and other production factors. These results will help producers optimize the sustainable

production of perennial feedstocks on less-productive cropland—not the prime farmland needed for food and feed crops like corn and soybean.

Find Genes, Tweak Production

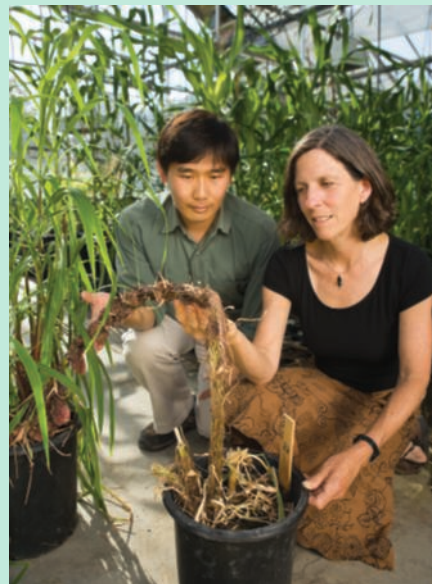
Back in the laboratory, chemical engineer Bruce Dien will be looking for traits in the switchgrass cultivars that are associated with how readily the plant’s sugars can be converted into biofuels. Dien works at the ARS National Center for Agricultural

Utilization Research in Peoria, Illinois.

“We’ll use expensive wet chemistry methods to identify the components linked to conversion efficiency and then use a near-infrared [NIR] instrument to record the light-wave signatures of each component,” Dien explains. “When we’re finished, we’ll be able to rapidly estimate the conversion yield of different perennial grass genetic lines using NIR instead of wet chemistry. This will be a much more

Same Plant, Different Project, Shared Goals

ARS geneticist Sarah Hake and University of California-Berkeley colleague George Chuck are conducting research that could have far-reaching implications for developing switchgrass as a biofuel crop. They have found that inserting a specific gene called *Corngrass* from corn into switchgrass essentially keeps the perennial grass in its juvenile form—a plant that doesn’t flower, produce seeds, or have a dormant growth phase.



ARS geneticist Sarah Hake and University of California-Berkeley colleague George Chuck study juvenile traits of corngrass. They have found that inserting a specific *Corngrass* gene into switchgrass keeps it in its juvenile form.

“Since these transgenic plants don’t flower, the starch doesn’t need to travel inside the plant to the inflorescence to support the flowering stage. Instead, the starch stays in the stem,” says Hake, who works at the ARS Plant Gene Expression Center in Albany, California. “The leaves are not nearly as stiff as leaves in a plant that hasn’t been modified. We also found that leaf lignin in transgenic plants is slightly different than leaf lignin in other plants.” Lignin modification will be a key factor in the commercial development of cellulosic ethanol,

because lignin structures must be broken down to release sugars that are fermented into biofuel.

“Since the starch is unused by the plant and stays in the stem, it allows for greater energy release,” adds Chuck. “We found up to a 250-percent increase in starch content and were able to extract more energy out of the biomass because of it.”

“Right now we’re introducing DNA segments called ‘genetic promoters’ to turn on the *Corngrass* gene in the shoot, but not the root, to help increase root mass development that is otherwise inhibited,” Hake says. “The development of nonflowering switchgrass varieties would eliminate the possibility that transgenes could escape into the environment and contaminate non-transgene plants. But we have a lot more work to do before transgenic switchgrass is ready for prime time.”—By **Ann Perry**, ARS.

PEGGY GREB (D1259-1)

cost-effective way for us to process the thousands of samples we need to study.”

Another ARS chemical engineer, Akwasi Boateng, will be looking for ways to streamline production of fuel via pyrolysis, a very-high-temperature conversion process where plant material is thermally decomposed in the absence of oxygen. Pyrolysis produces a dense bio-oil that can be readily converted into renewable jet, diesel, and other biofuels.

“We will collect pyrolysis data for 300 to 500 samples every year,” says

Boateng, who works in the Sustainable Biofuels and Co-products Research Unit at the ARS Eastern Regional Research Center, in Wyndmoor, Pennsylvania. “The samples will represent different production backgrounds and genetic materials. For instance, we’ll study different varieties of feedstocks, but we will also look at how harvest and storage management affects bio-oil yields. Then we’ll use the information to develop equations for predicting bio-oil yields, eliminating the need to conduct chemical analyses.”

Vogel, who has been working on switchgrass for more than two decades (see “[ARS and the Regional Biomass Research Centers](#),” pages 4-6), is optimistic that switchgrass and other North American perennial natives will someday become major components in U.S. agriculture for biofuel production.

“I’m glad that so many scientists are now working together on ways of establishing switchgrass as a bioenergy crop that can help the United States develop its own renewable energy sources,” Vogel says.—By [Ann Perry, ARS](#).

Molecular biologist Gautam Sarath (left) and geneticist Ken Vogel compare switchgrass plants that were produced by mating plants from upland and lowland ecotypes with their parents.



PEGGY GREB (D2614-1)

To reach scientists mentioned in this article, contact Ann Perry, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville MD 20705-5129; (301) 504-1628, ann.perry@ars.usda.gov. ❀

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

Soil scientist Virginia Jin samples greenhouse gas emissions from switchgrass in a long-term study of soil carbon sequestration.



PEGGY GREB (D2610-1)

Finding the Right Biofuels for the Southeast: A Range

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

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

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

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

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

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

ARS researchers working in Georgia, Louisiana, Nebraska, Hawaii, and elsewhere, with expertise in a wide range

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

Much of the USDA research effort in the South is focused on energy cane, napiergrass, and sweet sorghum (*Sorghum bicolor*). With its expertise, extensive network of university and industry partners, and vast collections of plant material available for research, ARS is uniquely equipped to play a pivotal role in developing all three of these grasses into viable feedstocks

for biofuels. ARS researchers are also working closely with companies that will produce biofuels so that they understand the companies' priorities and are using that insight in their efforts. It's an approach that is helping to accelerate progress toward lowering the potential costs of producing biofuels and making the biofuels price competitive with that of petroleum fuels.

The Sugarcane Connection

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



PEGGY GREB (D2606-1)

of Alternatives

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

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

“We don’t anticipate any energy cane being grown in the traditional sugarcane growing areas of Florida, Louisiana, Texas, or Hawaii,” says Ed Richard, who, prior to retiring in December 2011, led a

12-member energy cane research team at Houma. “We envision it being grown in the more northern zones of these states and in the other southern states, in rotations with pasture and other croplands that are not productive. In Hawaii, it may be grown on hilly land that is hard to irrigate,” he says.

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

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

Napiergrass: Right for Some, Maybe Not For All

Napiergrass, also called “elephant grass,” is a native of Africa and is used as cattle forage in much of the Tropics. Napiergrass offers advantages for the Southeast: It is drought tolerant and grows well on marginal lands and in riparian areas. It can also improve water quality

in riparian areas by filtering out nutrients in runoff from row crop fields.

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

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

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

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

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

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



PEGGY GREB (K10668-1)

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

Sorghum's Potential: How Sweet It Is

Sweet sorghum is a sturdy grass grown in the United States for livestock forage and for sugar for making syrup and molasses. But several attributes make it uniquely

suited as a bioenergy crop in the Southeast. It is drought tolerant; adapts to diverse growing conditions; has low nitrogen fertilizer requirements; produces abundant biomass; can be rotated with cotton and peanuts; and is compatible with equipment used to harvest, transport, and mill

sugarcane. It also contains soluble sugar that can be fermented directly into biofuel. The fiber (or bagasse) that remains after the sugar juice is extracted can be burned to generate electrical power—a strategy that South American sugarcane-producing countries are expanding.

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

Fuel-friendly varieties of sweet sorghum will need durable resistance to insect pests like fall armyworms and diseases such as maize dwarf mosaic. Breeders will also have to incorporate traits that prevent stalks from lodging, or toppling over, as they grow tall. Lodging is a problem because the crop will require mechanical harvesters. Fortunately, the Agricultural Research



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

Service has a long history of sweet sorghum research and germplasm development dating back several decades. Its sizeable germplasm collection contains 2,163 accessions of sweet sorghum from around the world, which are maintained by Gary Pederson and colleagues at ARS's Plant Genetic Resources Conservation Unit in Griffin, Georgia. Among other projects, scientists there are assessing the sugar profiles of select sweet sorghum accessions and genetically characterizing them using DNA markers so that plant breeders can develop varieties suited for biofuel production.

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

Molecular biologist Scott Sattler at Lincoln, Nebraska, is identifying genes, enzymes, and biochemical pathways involved in the crop's production of sucrose and other sugars. Ultimately, this will lead to new ways to ratchet up the activity of these genes or reengineer the pathways for even higher sugar yields than can be achieved with conventional plant-breeding methods. In New Orleans, scientists Gillian Eggleston, Sarah Lingle (retired), and Maureen Wright at ARS's Southern Regional Research Center are focused on developing industrial process technologies to manufacture sweet sorghum syrup for year-round storage and transport and to maximize biofuel yields and other value-added biobased products, such as succinic acid. They are also determining whether starch, aconitic acid, and other impurities slow down fermentation and need to be removed to reduce the costs of production.

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

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

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

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

In Tifton, Georgia, geneticist Bill Anderson measures the height of sorghum plants and practices for growing the crop on marginal soils.



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

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

The sweet sorghum improvement research work is one of several examples of work being done by researchers in Tifton to produce market-ready biofuel feedstocks. Environmental concerns are also a high priority being addressed by the Southeast Watershed Research Laboratory, in Tifton. “The lab is looking at potential effects

eight of energy cane in an experiment on production



PEGGY GREB (D2608-1)

on water quality, runoff, water-use efficiency, and carbon nitrogen pools in soils and plant tissue as biomass feedstock species are incorporated into Southeast agricultural systems,” Anderson says.—By **Dennis O'Brien** and **Jan Suszkiw**, ARS.

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

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

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



PEGGY GREB (D2609-1)

ARS Researchers Flying Higher With New Jet Fuels

In 2011, U.S. airlines burned through nearly 19 billion gallons of fuel, which goes a long way in explaining the establishment of “FARM to FLY,” a partnership among the U.S. Department of Agriculture, Airlines for America, Inc., the Boeing Company, and others to advance the development and production of aviation biofuel. Work by ARS scientists and their university and industry partners will help ensure that this effort pays off.

ARS chemist Terry Isbell is managing the workflow for scientists and support staff throughout the 4-year project, which is funded by USDA’s National Institute of Food and Agriculture.

“We’re looking for the ideal plant oils—and the ways to produce them—for making hydrotreated renewable jet fuel,” Isbell says, who works in the ARS Bio-Oils Research Unit at the National Center for Agricultural Utilization Research in Peoria, Illinois. “By taking a complete supply-chain systems approach, we’ll be able to reduce the costs of these fuels and make them more competitive with petroleum jet fuel.”

Project scientists are looking for genetic traits in oilseeds that enhance fuel production and using those traits to develop new oilseed strains for biofuel. They are focusing on improving sustainable production practices for oilseed crops and streamlining methods for pre- and postharvest oilseed processing. Achieving these objectives will help increase grower profits, lower feedstock costs for biorefiners, and improve the efficiency of conversion of rapeseed, a type of oilseed, to jet fuel.

“Every 1-percent increase in efficiency we can achieve in the hydrotreated renewable-jet-fuel supply chain reduces the production cost of each gallon by 5 cents,” adds ARS national program leader Jeffrey Steiner, who assembled the project team

and continues to participate in the research activities. “These costs savings can add up very quickly and could translate into significantly more business for agriculture.”

One Project, Many Options

To this end, Isbell and his colleagues will be cultivating varieties, experimental lines, and around 2,000 germplasm accessions of *Brassica napus*—industrial rapeseed, a nonfood variety of canola—in experimental trials in Arizona, California, Colorado, Idaho, Iowa, Minnesota, Montana, North Dakota, Oregon, and Texas. This will give scientists a range of oilseed material to work with as they assess how to maximize production and seed-oil yields for agricultural environments across the inland Pacific Northwest, the southern Great Plains Prairie Gateway, and the Northern Great Plains (see map on page 6).

These sites are also prime production areas for U.S. wheat, so the researchers want to identify rapeseed/wheat rotation systems that don’t disrupt food-crop production for biofuel production. They will also be collecting information to see how rotating rapeseed in wheat fields could help reduce erosion, increase water-holding capacities, and reduce the need for herbicides, while increasing dependable supplies of oilseeds for production. The Navy’s Office of Naval Research is helping to fund this work.

ARS scientists Michael Gore and Matthew Jenks are working with

University of Idaho plant breeder Jack Brown to sort through the genomes of each variety of rapeseed and find traits that can improve seed yield, oil yield, oil quality, and conversion efficiency of rapeseed oil to biofuel. The scientists will also identify traits that boost rapeseed tolerance to heat and cold, water stress, and other agronomic factors. Gore and Jenks work at the U.S. Arid-Land Agricultural Research Center in Maricopa, Arizona, and Jenks serves as coordinator for the Western Regional Center.

“This is a large testing population with tremendous trait variability, and the *Brassica* genome contains a significant amount of DNA variation at the population level,” says Gore. “So first we’ll sequence the thousands of genomic regions across individuals in the populations to catalog the extensive DNA variation. Then we’ll conduct statistical tests to identify associations between DNA variation and different traits. It will be like looking for the proverbial needle in a haystack with a magnifying glass.”

As part of this process, the researchers will work with Steve Lupton, Stan Frey, and others at Honeywell UOP to identify promising traits for biofuel processing. The ARS team will develop 1-gallon batches of bio-oil from the most promising oilseed candidates, and the UOP researchers will then assess the test fuels to determine which

oilseed genetic lines produce oils with the most favorable traits for renewable jet fuel production.

“Once we’ve identified important genetic traits that improve fuel production from oilseeds—whether it’s in the crop field or in the biofuel production process—we’ll be able to apply the results to the entire jet fuel supply chain. Another benefit from our work is that these results can be applied to edible canola oil, which

Brassica juncea is one of several oilseed crops being studied for potential use in biofuel production.



ROBERT EVANS (D2616-2)

is a variety of rapeseed, and other crops that provide significant amounts of seed oil such as cotton,” says Jenks. “We’ll also use the ARS SoyBase genomics database in Ames, Iowa, as a model for developing a genetic information system for *Brassica*.”

Tools of the Trade

Dan Long, who works at the Columbia Plateau Conservation Research Center in Pendleton, Oregon, and serves as the Northwestern Regional Center coordinator, is taking remote-sensing tools with a proven track record and studying how they can be used to assess seed-oil quality and quantity before and after harvest. For more than 30 years, near infrared reflectance (NIR) spectroscopy has been used as a rapid, nondestructive technique for measuring protein, moisture, and oil levels in whole grains.

Long used a specialized in-line NIR sensor to assess seed-oil content in 226 canola samples obtained over 6 years from sites in Montana, Oregon, and Washington. Oil concentrations in the samples ranged from 32 percent to 46 percent, and he found that the NIR sensor was able to predict seed-oil content with an average error of 0.73 percent.

Seed-oil concentration is used to estimate extraction efficiency, which is the percentage of oil recovered in relation to the amount of oil in seed. Long believes that NIR sensors could be installed in seed-crushing facilities to rapidly and continuously measure the oil content of clean seed flowing into the expeller. Using NIR to monitor extraction efficiency might enable crushers to adjust the choke setting on the expeller to compensate for oil loss in meal. This would boost profits associated with seed processing and lower the costs of the oil feedstock that is converted into jet fuel.

NIR measurements could also help optimize the amount of acreage used to produce oilseed crops for biofuel. “We might be able to reduce the number of acres needed for biofuel feedstock production by maximizing seed-oil extraction rates in the seed-crushing facilities,” Long explains. “And NIR sensing could be used to segregate the seed entering the plant into groups with low, intermediate, or high oil content. Each group could be



Physical research scientist John Sulik uses a hand-held radiometer to measure spectral reflectance from spring rapeseed in plots near Pendleton, Oregon. Spectral reflectance obtained with ground- and satellite-based sensors is being tested as a tool for predicting the crop’s nitrogen status, which may prove useful for predicting final oilseed traits desired by crushers and biorefiners.

processed at different times, depending on market demand.”

Long will also be using NIR information from aerospace remote sensing to predict oilseed traits desired by UOP and evaluate how within-field variability affects seed-oil characteristics and quality. And since some crushing facilities pay a premium to growers for maximizing the oil concentration of their oilseed crops, a NIR instrument mounted on a GPS-equipped combine would give growers the ability to map fields according to oil concentrations in the seeds and estimate the subsequent dollar value of the crops.

Taking Care of Business

The Navy Office of Naval Research is also funding an assessment of the infrastructure needed to support production and transport of the jet fuel, with help from the U.S. Department of Transportation’s Volpe National Transportation Systems Center in Cambridge, Massachusetts. Agricultural economist Dave Archer, who works at the ARS Northern Great Plains Research Laboratory in Mandan, North Dakota, is helping to develop decision tools to find the most sustainable ways to grow oilseed crops that also minimize greenhouse gas production and reduce negative impacts on wheat markets and water quality. And

business developer Terry Tomlinson, who works at the National Feedstock Resource Center in Enid, Oklahoma, will help expand business networks via meetings with growers and other commodity partners who could contribute resources toward successful development of biofuel chains.

“From start to finish, we want to provide the information that industry and agriculture will need to support hydrotreated renewable jet fuel production,” Isbell says. “These are new crops for many farmers, and it’s important for them to know that if they make a switch, they can still turn a profit. In the end, we want results that are adopted and useful—and that lead to biofuels for commercial and military aircraft.”—By **Ann Perry, ARS**.

To reach scientists mentioned in this article, contact Ann Perry, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1628, ann.perry@ars.usda.gov. ❀

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

Pink Lemonade, Razz, and More!

Anyone who grows backyard blueberries knows that some of the berries may turn pink before they finally ripen to a familiar dusty blue.

When a Pink Lemonade blueberry is ripe and ready to eat, however, it is, in fact, pink.

Though not a first, this intriguing coloration is “still somewhat unusual” for a ripe, harvest-ready blueberry, according to Agricultural Research Service plant geneticist Mark K. Ehlenfeldt.

Ehlenfeldt has his laboratory, greenhouse, and test plots at the Philip E. Marucci Center for Blueberry and Cranberry Research and Extension in Chatsworth, New Jersey, about 60 miles south of Newark in the state’s pine barrens.

Here’s more about Pink Lemonade and a glimpse of several other interesting blueberries developed through the Chatsworth research.

Pink Lemonade: Pretty and Tasty

Pink Lemonade “may be the prettiest blueberry around,” says Ehlenfeldt. This plant bears moderate yields of firm, glossy, medium-sized berries, with a mild flavor that Ehlenfeldt describes as “sweet and flowery.” It ripens from mid-late to late season. In New Jersey, that’s usually mid to late July.

“Pink Lemonade is also a nice plant for landscaping,” Ehlenfeldt says. “It has

shiny green leaves in spring and summer and dusky, reddish-brown twigs in winter.”

Ehlenfeldt says Pink Lemonade is suited for U.S. Department of Agriculture Plant Hardiness Zone 6—where the weather, on average, never gets colder than 0°F—and for milder regions.

Pink Lemonade resulted from the crossing of two parent plants—an experimental blueberry developed by Nicholi Vorsa, a Rutgers University scientist stationed at the Chatsworth center, and a commercial blueberry, Delite, which was developed by USDA and the University of Georgia. Ehlenfeldt crossed these two plants in 1991 and, in 1996, chose one of the offspring—designated as “Selection Number ARS 96-138”—for further testing.

While Ehlenfeldt was scrutinizing the plant’s performance in New Jersey test plots, colleague Chad E. Finn, a plant geneticist in the ARS Horticultural Crops Research Unit in Corvallis, Oregon, was evaluating it on the West Coast, in response to interest by the plant nursery industry in that region.

Based on that interest and the good scores that ARS 96-138 achieved in these evaluations, the scientists formally released the variety in 2005, assigning the selection number as its identifier. In 2007, to help build market identity for the plant,

the researchers named it “Pink Lemonade.” In that same year, the novel blueberry garnered a “best new shrub” honor at the prestigious Far West Horticultural Show. You can find “Pink Lemonade” for sale in garden catalogs and on the web.

Razz: Its Flavor Will Surprise—and Please

Razz is a blueberry with a taste that’s rather surprising. Its name is a hint: Razz tastes quite a bit like a raspberry.

“The remarkable raspberry overtones make Razz unlike any other commercial blueberry that we know of,” says Ehlenfeldt.

Razz is a “rediscovered” blueberry. It was bred in 1934 by USDA’s first blueberry breeder, Frederick V. Coville. It was selected for further study by USDA scientist George M. Darrow and Rutgers plant breeder J.H. Clarke in 1941.

After that, it “just hung around for a long time,” says Ehlenfeldt. “It was considered unsuitable for large-scale commercial production because it was too soft for shipping or storing. And, although people appreciated its flavor, the berry was simply too different for the times.

“Eventually, several nurseries expressed an interest in growing and marketing it to backyard gardeners. We decided to test it here in New Jersey and released it in 2011.”

MARK EHLENFELDT (D2598-1)



Left: Pink Lemonade blueberries have a sweet, mild, flowery flavor and a pretty pink color.

Right: Razz blueberries offer a taste of raspberry.

MARK EHLENFELDT (D2599-1)



Wonderful Blueberries From ARS to You

Razz produces good yields of medium to large berries that ripen in midseason. “In New Jersey, that is the end of June through the first week or two of July,” Ehlenfeldt says.

“Razz should do well in most places where northern highbush blueberries can be grown. Growers, pick-your-own farms, and backyard gardeners might want to give this specialty berry a try.”

Sweetheart: A Berry To Begin—and End—the Growing Season

Sweetheart may be the perfect plant for those who just can’t wait for the first blueberries of the growing season—and, of course, hate to see the season end.

That’s because Sweetheart meets both needs. It produces firm, delectable, medium to medium-large berries early in the season, about mid-June through the end of the month. Then, if the autumn is mild, Sweetheart may reflower and refruit, Ehlenfeldt says. “The autumn yield is not really large enough to be called a ‘second crop,’” he explains, “but it’s a nice treat at a time when most blueberry plants have long since stopped fruiting.” Late-season refruiting is “a somewhat unusual trait,” he notes.

Sweetheart berries have “a superior flavor that lasts, even in storage,” he says. That’s unlike some blueberries, which “be-

gin to lose some flavor soon after they’ve been picked.”

Well suited for commercial growers, Sweetheart is “great for home gardens, too,” says Ehlenfeldt who, in 1996, made the cross that resulted in today’s Sweetheart plants. In 1999, he chose it—from among other candidate seedlings—for further study, continued testing it at Chatsworth through 2009, then formally released it as a named variety in 2010.

Sweetheart can be grown in USDA Plant Hardiness Zone 5—where temperatures usually won’t get colder than -10°F , on average—and in milder zones. What’s more, some preliminary studies “suggest that Sweetheart may also be hardy in regions colder than Zone 5,” says Ehlenfeldt.

Cara’s Choice: Outstanding Flavor

Cara’s Choice is “regarded by some blueberry aficionados as having the best flavor of any blueberry,” says Ehlenfeldt. “This is a very sweet, medium-sized blueberry, with a pleasant aroma.”

Even though its yields are only moderate—about 35 percent less than industry standards such as Bluecrop, for example—this berry nonetheless offers growers the significant advantage of keeping its quality while still on the bush. “That’s a plus,” notes Ehlenfeldt, “because it allows growers to distribute their harvests over a longer

period of time.” Meanwhile, the berries’ sweetness tends to increase.

“The berries can stay on the plant for several weeks after ripening, without losing flavor or firmness,” he reports.

Best for Zone 6 and milder zones, this berry is ready for harvest in midseason.

Blueberry researcher Arlen D. Draper, formerly with USDA in Beltsville, Maryland, and now retired, made the cross that yielded today’s Cara’s Choice in the late 1970s and, in 1981, singled it out for further study. Since then, evaluations at the Atlantic Blueberry Company and at Variety Farms—both in Hammonton, New Jersey—by Draper; Ehlenfeldt; now-retired ARS scientists Gene J. Galletta and Allan W. Stretch; and Rutgers’s Vorsa led to the plant’s release in 2000.

Ehlenfeldt expects to have yet another superb blueberry ready to introduce in the near future.—By **Marcia Wood, 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.

*To reach the scientists featured in this article, contact Marcia Wood, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5129; (301) 504-1662, marcia.wood@ars.usda.gov.**

MARK EHLENFELDT (D2600-1)



Left: The superior flavor of Sweetheart blueberries isn’t lost during storage.

Right: Some blueberry fans say Cara’s Choice is the best one they’ve ever tasted.



MARK EHLENFELDT (D2601-1)



Making Fruit Flies More Macho for Sterile Insect Releases

The Mexican fruit fly, *Anastrepha ludens*, is considered a significant quarantine pest that could cause billions of dollars in losses to citrus, peach, pears, avocado, and other crops were it to move into the United States from Mexico.

Fortunately, Mexico, in cooperation with the U.S. Department of Agriculture's Animal and Plant Health Inspection Service, has an aggressive program in place to counter the threat posed by the green-eyed, 1-centimeter-long fly. The program's ultimate target, though, is not the adult insect, but rather its larval stage, during which it feeds inside the fruit of host crops, rendering them unfit for consumption or sale.

At the heart of Mexico's anti-fly program is the sterile insect technique (SIT), which involves sterilizing millions of male fruit flies with irradiation and

releasing them en masse to mate with wild female flies. Such matings result in nonviable eggs that fail to hatch. Over time, repeated releases of sterile male flies cause the targeted pest population to collapse, diminishing or eliminating the need for insecticide spraying.

Methoprene-treated flies produce more pheromone and attract more females to mate with than do flies that are just irradiated.

Now, a new advance promises to improve the SIT program's effectiveness and save on operational costs associated with rearing the flies. An international team of scientists from the Agricultural Research Service and other organizations has shown that an analogue of the insect hormone methoprene can be used to speed up the rate at which male flies reach sexual maturity. This means that the flies are ready for release sooner than the standard 7 to 9 days.

"In every case, we more than halved the time it took the flies to sexually mature.

Above Left: To accelerate reproductive development of some fruit fly species, ARS physiologist Peter Teal topically applies methoprene to a newly emerged adult male Caribbean fruit fly.

Above Right: Close-up of the fly receiving a topical application of methoprene.

We could release them at 4 days old,” says Peter Teal, a principal investigator on the team and the research leader in ARS’s Chemistry Research Unit in Gainesville, Florida.

What’s more, the methoprene treatment “makes the flies more macho,” says Teal, whose collaborators included researchers in Mexico, Argentina, and Austria. Compared to the untreated males, methoprene-treated flies produce more pheromone and attract more females to mate with than do flies that are just irradiated.

In addition to studying methoprene’s effects on Mexican, Caribbean, and other tephritid fruit flies, as well as nutritional requirements for the species’ pheromone signaling and reproductive success, the team devised large-scale methods of treating the insects. These methods included development of an adult diet, in the form of a paste, which contains methoprene and costs only \$13 per 1 million released flies.

Other research by the team involves adding amino acids from hydrolyzed protein to the fruit fly diet, which makes them more robust and better able to escape predators when released into the wild. Most importantly, “they mate better with feral female flies,” adds Teal.

In laboratory trials, sterile male flies fed a diet containing 0.05 percent or 0.1 percent of methoprene and hydrolyzed protein were ready to mate 4 to 5 days sooner than untreated males and produced more pheromone, to boot. Outdoor trials were also successful.

Use of methoprene or hydrolyzed protein alone did not work as well as when the two were combined, and not all species responded to the treatment—Mediterranean and Oriental fruit flies being two.

Nevertheless, “the methods to incorporate these technologies into mass rearing of sterile flies and the technique are now in use for control of the Mexican fruit fly in Mexico,” notes Teal, who coauthored a paper in the April 2011 issue of *Journal of Applied Entomology*.

Data collected from SIT-treated areas of Rio Verde by the Mexican National Campaign Against Fruit Flies indicates that the population of *A. ludens* flies there has been reduced to below 0.01 fly per trap per day.—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.

Peter Teal is in the USDA-ARS Chemistry Research Unit, Center for Medical, Agricultural, and Veterinary Entomology, 1600-1700 S.W. 23rd Dr., Gainesville, FL 32608; (352) 374-5730, peter.teal@ars.usda.gov. ❀

At the Center for Medical, Agricultural, and Veterinary Entomology in Gainesville, Florida, Peter Teal collects sterilized male Caribbean fruit flies to evaluate the effects of methoprene in accelerating sexual development.



STEPHEN AUSMUS (D2580-3)

Banking on Plants as Storehouses

Tomatoes account for more than \$2 billion in farm income nationwide each year. But the silverleaf whitefly (*Bemisia tabaci*) cuts into those revenues, spreading a virus known as tomato yellow leaf curl virus (TYLCV) that can wipe out an entire crop. To compound the problem, a new biotype of silverleaf whitefly is raising concerns because it is resistant to insecticides and has spread to 26 states since its discovery in the United States in 2004. The threat is taken seriously in Florida, where growers raise up to 40,000 acres of fresh-market tomatoes each year.

Cindy L. McKenzie, an Agricultural Research Service entomologist in the Subtropical Insects Research Unit in Fort Pierce, is showing how growers can combat the silverleaf whitefly and other crop pests by using plants as storehouses for predatory insects that can migrate to tomatoes and other cash crops and feed on the pests.

Choosing the Right Banker

McKenzie teamed up with Lance S. Osborne, an entomologist at the University of Florida Mid-Florida Research and Education Center, Apopka, Florida; and Yingfang Xiao, a postdoctoral associate researcher, to do extensive work showing how papaya, corn, and ornamental peppers can serve as “banker plants” for a range of insect parasitoids and predators. The approach is considered an environmentally

friendly alternative because it reduces insecticide use and offers growers a low-cost, self-perpetuating alternative, McKenzie says. The predators eat what they find on banker plants and then fly or crawl off to find the targeted pest on the cash crop. But before they disperse, most will lay eggs on the banker plants, which extends the effect into subsequent generations. Lower pesticide use also means pests like spider mites, thrips, and whiteflies—known to develop resistance to insecticides—will be less likely to become resistant.

Many Florida greenhouse operators pollinate tomatoes with bumble bees, and that makes them reluctant to use insecticides. Banker plants can be potted and moved around a greenhouse if a grower wants to spray insecticides in one area and keep other areas insecticide free.

“When you use banker plants, you are tapping into nature’s ability to regulate

itself, and that’s an approach that has all kinds of potential,” McKenzie says.

Using banker plants is a balancing act that requires finding the right combination of plant, predator, and targeted pest. Researchers must select insect predators and an alternative prey for those predators, and neither should be able to damage the cash crop. They also need banker plants and predators that will not host or spread diseases like TYLCV to the cash crop.

“You can’t just put the predator in and hope for the best. You need a food source for it—an alternative prey—and you need to be sure that the alternative prey doesn’t become a pest itself,” she says.

In a study designed specifically for Florida’s greenhouse poinsettia operations, the researchers chose papaya (*Carica papaya*) for their candidate banker plant, and they chose the parasite *Encarsia sophia*, a tiny, nonstinging wasp whose larvae feed on the

Technician Katherine Houben (from the University of Florida) looks for beneficial insects on a papaya plant serving as a “banker plant” in a crop of poinsettias. Banker plants attract beneficial insect parasitoids and predators that can help control pests.



WILLIAM C. FOOSHEE (D2593-1)

silverleaf whitefly. Previous work showed that *E. sophia* attacks numerous types of whiteflies and that a possible food source for it, the papaya whitefly (*Trialeurodes variabilis*), does not like poinsettia, and in fact doesn't seem to like anything but papaya. The researchers also knew that as a Florida native, *E. sophia* poses no threat to the state's habitats.

"It's out there in nature, and people don't even know it's there," McKenzie says.

The researchers also needed to make sure that *E. sophia* would still feed on the silverleaf whiteflies after eating the papaya whiteflies. So they observed *E. sophia* under two sets of test conditions. In one, they essentially forced the wasps to eat the targeted prey to make sure they would control it when given no dietary choices. In another, they gave them a choice between the prey they were supplying as a food source and the targeted pest they want to eradicate.

"If they like them both equally, that's a good thing because it means they can survive on one insect while they control the other," McKenzie says.

Their results, published in *Biological Control*, show that *E. sophia* has an appetite for both the alternative prey and silverleaf whiteflies and that it effectively wipes out any silverleaf whiteflies it finds on poinsettias growing near the papaya banker plants.

This banker plant system is now being tested for application in commercial greenhouse tomato production. The limiting factor in adoption by tomato growers was proving that papaya was not a host plant for TYLCV. In a second paper, in *Florida Entomologist*, the researchers went a step further, showing that papaya is not susceptible to the TYLCV commonly spread by silverleaf whiteflies and that the papaya whitefly, used as the food source for *Encarsia*, will not infect the tomato plants with TYLCV because they do not feed on tomato.

Beyond Poinsettias, Tomatoes, and Whiteflies

McKenzie, Osborne, and Xiao have also shown that corn will bank a gall midge that effectively controls the two-spotted spider mite. The gall midge has been previously used as a biocontrol for the mite, which attacks green beans and other greenhouse vegetables. But their work, published in *Crop Protection*, is the first to show how a banker system can be used to effectively "store" the midges.

The research team is also studying whether different varieties of ornamental peppers can bank a type of predatory mite, *Amblyseius swirskii*, that is effective at controlling whiteflies and thrips in Florida's greenhouses. Results so far are extremely promising, and the concept is catching on among growers.



Encarsia sophia, a tiny nonstinging wasp whose larvae feed on the silverleaf whitefly.

Stephen Mullen, general manager at Knox Nursery in Winter Garden, Florida, was initially skeptical about using insects to control the whiteflies that attack poinsettias in his greenhouse. But the nursery is interested in cutting back on insecticide use. So 2 years ago, as part of a cooperative arrangement with McKenzie and Osborne, he began using a combination of banker plant systems: predatory mites banked on ornamental peppers and nonstinging wasps banked on papaya plants. Though the work is continuing, Mullen is pleased with the results so far. The predators have managed to control the whiteflies largely on their own, so the nursery is using very little insecticide in its production of poinsettias.

"I'm convinced this is working. It is absolutely working," he says.

The research is funded with grants provided by the U.S. Environmental Protection Agency through the Pesticide Registration Improvement Act and by the U.S. Department of Agriculture's Floriculture and Nursery Research Initiative.—By **Dennis O'Brien, ARS.**

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

Cindy L. McKenzie is in the USDA-ARS Subtropical Insects Research Unit, 2001 South Rock Rd., Fort Pierce, FL 34945; (772) 462-5800, cindy.mckenzie@ars.usda.gov. ❁

ARS entomologist Cindy McKenzie inspects poinsettias for damage during tests of ornamental peppers as banker plants that host beneficial predatory mites. One of the ornamental pepper plants is nestled about 2 feet in front of her among the poinsettias.



LANCE OSBORNE (D2592-2)

A Cautionary Note

At least once a day, many of Idaho's 550,000 dairy cows wade through shallow copper sulfate baths to help prevent foot infections. Producers often discard the bath water into lagoons and eventually use the spent wastewater to irrigate corn and alfalfa.

"At some point, the buildup of copper in the soil could start to negatively affect crop production," says soil scientist Jim Ippolito, who works at the Agricultural Research Service's Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho. "By studying this issue now, we may be able to help producers develop irrigation management strategies that keep copper from getting to potentially harmful levels."

Ippolito joined with ARS soil scientist David Tarkalson and microbiologist Tom Ducey to study how copper levels in the wastewater affected crop performance and soil microbial activities. Tarkalson also works in Kimberly, and Ducey is with ARS's Coastal Plains Soil, Water, and Plant Research Center in Florence, South Carolina.

The scientists selected two soils common to south-central Idaho, where many dairies are located. Then they conducted a lab study of alfalfa growth in soils containing copper at levels of 50 parts per million (ppm), 100 ppm, 250 ppm, 500 ppm, or 1,000 ppm.

Copper sulfate at soil levels of up to 250 ppm had no effect on alfalfa growth, but alfalfa growth stopped when soil copper sulfate levels exceeded 500 ppm. The alfalfa plants took up higher levels of copper at both application rates, and from 48 to 80 percent of the added copper was still in the soil and available to plants at the end of the study.

The team also discovered that beneficial soil bacterial activity declined when the two soils accumulated available soil copper levels above 50 ppm. And a correlation analysis indicated that soil levels above 63 ppm of plant-available copper resulted in alfalfa copper concentrations that

could potentially harm grazing livestock, according to guidelines established by the National Research Council.

Ippolito also conducted a laboratory study of whether biochar made from pecan shells could reduce copper levels in the spent wastewater. He tested the biochar in solutions with varying pH levels and found that the amount of copper adsorbed, or "captured," by the biochar could be as much as 40,000 ppm. He concluded that it might be possible to use biochar to clean up waters containing elevated copper levels, but that more studies would be needed to identify characteristics that would allow the biochar to capture the most copper.

Ippolito published his findings in the *Journal of Agricultural Science, Soil Science*, and the *Journal of Environmental Quality*.

"In our studies, we controlled how much copper was added to the soil. But in real-world conditions, soil copper accumulations and their effects will vary depending on a range of factors, including how often crops are irrigated, how much copper is in the

wastewater, and how much copper remains in plant-available form," Ippolito says. "We might not see any negative impacts for anywhere from 15 to 75 years after irrigation begins. But producers should be proactive and work with us to address this issue sooner rather than later."—By **Ann Perry, ARS**.

This research is part of Climate Change, Soils, and Emissions (#212), Agricultural and Industrial Byproducts (#214), and Water Availability and Watershed Management (#211), three ARS national programs described at www.nps.ars.usda.gov.

Jim Ippolito and David Tarkalson are with the USDA-ARS Northwest Irrigation and Soils Research Laboratory, 3793 N 3600 E, Kimberly, ID 83341-5076; (208) 423-6524 [Ippolito], (208) 423-6503 [Tarkalson], jim.ippolito@ars.usda.gov, david.tarkalson@ars.usda.gov.

Tom Ducey is with the USDA-ARS Coastal Plains Soil, Water, and Plant Research Center, 2611 West Lucas St., Florence, SC 29501-1242; (843) 669-5203 ext. 112, thomas.ducey@ars.usda.gov.

Many of Idaho's dairy cows wade through copper sulfate baths like this to help prevent foot infections. ARS scientists are studying how copper levels in the wastewater affect crop growth and soil microbes.



ERNEST HOVINGH, PENN STATE UNIVERSITY (D2630-1)

About Copper Footbaths for Dairy Cows

Locations Featured in This Magazine Issue



Locations listed west to east.

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

Plant Gene Expression Center, Albany, CA

1 research unit ■ 12 employees

Corvallis, OR

3 research units ■ 133 employees

Columbia Plateau Conservation Research Center, Pendleton, OR

1 research unit ■ 17 employees

Northwest Irrigation and Soils Research Laboratory, Kimberly, ID

1 research unit ■ 40 employees

U.S. Arid-Land Agricultural Research Center, Maricopa, AZ

3 research units ■ 79 employees

Northern Great Plains Research Laboratory, Mandan, ND

1 research unit ■ 42 employees

Lincoln, NE

2 research units ■ 81 employees

Center for Grain and Animal Health Research, Manhattan, KS

5 research units ■ 129 employees

Ames, IA

8 research units ■ 535 employees

Madison, WI

5 research units ■ 129 employees

National Center for Agricultural Utilization Research, Peoria, IL

7 research units ■ 226 employees

Houma, LA

1 research unit ■ 48 employees

Southern Regional Research Center, New Orleans, LA

7 research units ■ 181 employees

Griffin, GA

1 research unit ■ 20 employees

Tifton, GA

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, SC

1 research unit ■ 36 employees

U.S. Horticultural Research Laboratory, Fort Pierce, FL

4 research units ■ 148 employees

Canal Point, FL

1 research unit ■ 40 employees

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

30 research units ■ 953 employees

Eastern Regional Research Center, Wyndmoor, PA

6 research units ■ 190 employees



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 at ars.usda.gov/ar • Follow us at twitter.com/USDA_ARS