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LOUISIANA Agriculture

Assuring Our Future Through Scientific Research and Education

Soybeans Vital for Louisiana Agriculture

LSU AgCenter
Research & Extension

Soybean research helps solve today's problems, train tomorrow's leaders

(Editor's Note: John Russin, formerly the associate vice chancellor, was named the vice chancellor for research at the LSU AgCenter and director of the Louisiana Agricultural Experiment Station on June 24, 2011.)

Soybean is one of the many commodities that comprise the rich mosaic that is Louisiana agriculture. Its benefits to row crop production have long been known, including its ability to enrich our soil through nitrogen fixation and to serve as an attractive, profitable rotation crop.

Louisiana's semitropical climate, occasional hurricanes, crop rotation practices and wide array of pests are among the many factors that make soybean production in our state, indeed across much of the Gulf South, a challenge. But that challenge provides opportunity for LSU AgCenter scientists to develop into the most problem-focused, well-rounded and grower-engaged professionals around. Not only must they become expert in constraints that affect soybean, but they must also understand these constraints as they impact crops grown in rotation. This requires practical familiarity with agronomic practices, inputs and infrastructure for an array of crops. Consequently, our scientists develop skills and expertise far beyond the original arena in which they were hired, which in turn makes them far more valuable members of our crop production team.

At no time are these skills and expertise more valuable than when new pests emerge. LSU AgCenter soybean scientists are at the vanguard of emerging pest issues in the United States. One need only consider the recent threats posed by Asian soybean rust and redbanded stinkbug to understand the critical need to first identify and then meet such problems head-on. These emerging issues also provide a hidden benefit in that the rest of the nation, indeed the world, can see and appreciate the teamwork, responsiveness and resourcefulness of our AgCenter scientists.

We are aided greatly by a well-engaged stakeholder group, the Louisiana Soybean and Grain Research and Promotion Board. This appointed board administers the soybean checkoff funds in our state, which provide for an effective partnership between producers and scientists. Not only does this board support applied soybean research, but they also ensure clear communication such that AgCenter professionals understand and address the most pressing needs. In this way, the Soybean and Grain Board serves effectively in an advisory capacity by providing funding to programs that have the greatest relevance and show greatest potential for success. This desirable arrangement helps build into our faculty the problem-solving mindset that has long been our AgCenter hallmark.

Soybean research provides information support to Louisiana's crop consultants. These business professionals, many of whom received their education and training with AgCenter faculty, rely heavily on AgCenter research for the latest in crop and pest management information. Such a positive relationship has allowed this essential niche industry to thrive in Louisiana while being absent in some states with substantially greater soybean acreage.

Yet another benefit of soybean research in Louisiana is the opportunity to train the next generation of scientists. Our AgCenter professionals have demonstrated excellence throughout their careers, and they labor to instill that excellence in graduate students who pursue advanced degrees under their direction. As world population grows and living standards increase, we must provide the trained professionals needed to meet projected demands for food, feed and fiber.

The LSU AgCenter is proud of its reputation in solving today's problems and training tomorrow's leaders, and we are dedicated to making Louisiana agriculture financially profitable, environmentally sustainable, and socially responsible.
■ **John Russin**

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Linda Foster Benedict, Editor
Louisiana Agriculture
P.O. Box 25100
Baton Rouge, LA 70894-5100
tel (225) 578-2263
fax (225) 578-4524
lbenedict@agcenter.lsu.edu

www.LSUAgCenter.com

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Cover illustration by John Wozniak

Campus Dairy Store still cool after 40 years

Photo by Johnny Morgan

LSU AgCenter dairy science professor Chuck Boeneke chats with LSU AgCenter employee Ronda Clark as she enjoys an ice cream cone at the Dairy Store.

From its humble beginnings in 1973 as a project between the student government association and the Dairy Science Department, the popularity of the LSU Dairy Store remains strong.

For many, grabbing an ice cream cone from the store is one of the highlights of their visit to the LSU Baton Rouge campus.

But ice cream is but one of the many items now available from the store, according to LSU dairy science professor Chuck Boeneke.

"We now have meats such as lamb, beef, pork and goat," he said. "We also have sandwiches, different cheeses and coffee drinks in addition to ice cream."

The store recently began selling boudin and hot sausage poboys, Boeneke said.

In addition to products at the South Stadium Drive location, the store also provides ice cream to cafeterias across the campus and has sold ice cream at home football games.

Funded by the LSU main campus and the LSU AgCenter, the Dairy Store's ice cream and cheese are made from milk supplied by the AgCenter's dairy farm and brought to the creamery, which is a research and teaching facility.

The creamery is the manufacturing facility that allows students to learn the process of making ice cream and cheese.

Most of the work at the store is done by students who can be from any major.

"When we are really busy, we probably are selling somewhere between 250 and 300 gallons of ice cream per week," Boeneke said.

In addition to cones and cups of ice cream, customers also can buy three-gallon buckets.

"Our ice cream is made with nonfat dry milk, cream and pure cane sugar," he said.

Several departments on campus conduct research at the creamery as well as people from private industry who come to learn from the work there.

"We had a joint project with Southern University and the University of Liberia, where we did a mentoring program, and one of the ladies from Africa was in the ice cream business," Boeneke said. "She came and spent a few months here, and I mentored her – showing her how the store works." ■ **Johnny Morgan**

Sanders testifies on giant salvinia invasion

SHREVEPORT, La. – A Brazilian weevil that feeds on giant salvinia is a biological control for the invasive species that has been taking over water bodies in Louisiana since it was first discovered in the state in the Toledo Bend reservoir in 1999.

Dearl Sanders, LSU AgCenter weed scientist, gave testimony on how the weevil works at a Congressional Natural Resources Subcommittee hearing led by U.S. Rep. John Fleming, R-La., and U.S. Rep. Louis Gohmert, R-Texas, at LSU-Shreveport on June 27.

Sanders was invited to offer their ideas for control or eradication strategies of the invasive species and costs involved.

Giant salvinia spread from Brazil to many areas of the world in the 1950s and 1960s. Experts have employed several control measures, including herbicide sprays, mechanical control, booms, drawdowns, educating the general public and weevils. The LSU AgCenter has been investigating control measures for giant salvinia since 1999, Sanders said.

In partnership with the Louisiana Department of Wildlife and Fisheries, the LSU AgCenter helped collect and transport more than 30 tons of weevil-infested giant salvinia with approximately one million weevils to Lake Bistineau near Bossier City and four other north Louisiana lakes in 2009.

Sanders said the weevils have reduced salvinia 90 percent in some areas in south Louisiana, but they have not survived the cold winters in the Shreveport area. He said research needs to be directed on finding a strain that can accommodate low winter temperatures.

The LSU AgCenter has helped establish weevil nurseries in Lafourche, Terrebonne and St. Charles parishes. The initial weevil nursery in Gheens was used to develop the protocol for salvinia and weevil production, the timeline for weevil population growth and the optimum times for weevil harvest and distribution.

Sanders noted that weevils don't fly. "This is important in planning a distribution system, since any movement of weevils from one place to another that is not directly connected by water is unlikely," he said. "Man has to move them from point A to point B, and it is labor intensive."

Sanders also has conducted an extensive grass carp biological control study that confirmed that grass carp will not eat giant salvinia even when it is the only plant available. "Grass carp only eating giant salvinia died," Sanders said. "Giant salvinia contains a metabolic toxin."

Sanders said it was "the nastiest trial I ever ran in my life." ■ **Mary Ann Van Osdell**

Louisiana seafood good choice for summer grilling

Louisiana seafood is fast and easy to grill for summertime eating enjoyment because it has smaller percentages of skeletal and connective tissues than equal portions of red meats or poultry, according to LSU AgCenter nutritionist Beth Reames.

"Louisiana seafood is safe, nutritious and tastes great," Reames said. "It's an excellent source of protein, low in fat and saturated fat, and contains heart-healthy omega-3 fatty acids."

Reames' tips for perfectly grilled seafood include:

– Preheat an outdoor gas or electric grill for at least 10 minutes. If you use a charcoal grill, start the fire about 30 minutes before cooking, let it burn until the coals are white-hot, and then spread the coals out in a single layer.

"A moderately hot fire of 375 to 425 degrees Fahrenheit is best for cooking seafood," Reames said.

– Make sure that the grill grates are clean, and then lightly brush them with vegetable oil to prevent sticking.

– Place the oiled grate on the grill, and adjust the grill height to 4 to 6 inches above the heat.

"Prepare seafood for grilling by lightly spraying both sides of it with olive oil or vegetable oil (away from direct flames) and then sprinkle it with desired seasonings," Reames said. "Avoid brushing or rubbing the seafood with your hands to prevent cross-contaminating other foods."

Marinating fish an hour before grilling also helps keep it moist. Remove excess marinade before grilling to avoid flare-ups. If you are going to use the marinade as an extra sauce on top of the cooked fish or seafood, boil the marinade at a rolling boil for 5 minutes to prevent foodborne illness.

– Finfish and large shrimp may be placed directly on the grate. Put smaller varieties in an oiled fish basket, on a small-mesh seafood-grilling screen or on perforated aluminum foil for easier handling and to prevent sticking.

– Cook small whole or butterflied fish, fish steaks, fillets, kabobs, crabs, shrimp and shellfish directly over the heat source.

To estimate cooking time, measure the seafood at its thickest part, Reames says. Grill for 10 minutes at approximately 400 degrees Fahrenheit for each inch of thickness. Fish is done, but still moist, when it turns opaque and just starts to flake when tested with a fork.

"Most seafood needs to be turned halfway through cooking," she says. "Fish fillets less than 1 inch thick don't need to be turned. Avoid turning fish more than once because this will break the fish apart."

■ **Rick Bogren**

Rice acreage reduced, salt water threatens fields

LAKE ARTHUR, La. – U.S. rice acreage has fallen significantly, and that could affect prices, according to LSU AgCenter economist Mike Salassi.

"Every rice state with the exception of California reduced rice acreage this year," he said. The U.S. Department of Agriculture's latest figures show Louisiana's 2011 rice acreage at 420,000 acres, 120,000 acres fewer than last year.

Arkansas acreage is at 1.1 million acres, compared with 1.79 million last year, and it is that state's lowest since 1989. Nationwide rice acreage is 2.6 million acres, down by 960,000, Salassi said, and it is only the fourth time in the past 15 years that the total is less than 3 million acres.

Prices this time last year were $17 to $20 a barrel, compared to the $20-per-barrel range now, and he said he expects prices to increase through January. "We should have prices in the $23-a-barrel range."

One reason rice acreage has declined in Louisiana is high levels of salt in some fields.

Rice plants in a field southeast of Gueydan had a salt content of 4,096 parts per million, said Stuart Gauthier, LSU AgCenter county agent in Vermilion Parish. The LSU AgCenter recommends against planting rice in soils with levels exceeding 750 ppm.

The field had been flooded with salt water from a hurricane, but it showed no problems two years ago, Gauthier said. Then the farmer plowed and laser-leveled the field, and apparently that moved salt concentrations into the higher levels of the soil profile.

Chad Courville, land manager for Miami Corp., asked farmers for their support in a request to the U.S. Army Corps of Engineers to manipulate locks along the coast to attempt to get fresh water into the marshes. He said much of the marshland is completely dry.

Photos by Bruce Schultz

LSU AgCenter economist Mike Salassi, far right, tells farmers at a July Vermilion Parish Rice Field Day about the rice acreage decline in the nation.

The locks at Schooner Bayou and Freshwater Bayou could be manipulated, he said.

"If we're going to do this," Courville said about approaching the corps, "we need to do it in a unified voice."

The corps has agreed to coordinate operations at Catfish Locks and Calcasieu Locks to move more freshwater into the Mermentau Basin, a request that resulted from a meeting held last month by the LSU AgCenter in Lake Arthur, he said. ■ **Bruce Schultz**

Farmers in a field east of Gueydan listen to Natalie Hummel, LSU AgCenter entomologist, describe how early planting affects rice water weevil populations.

OVERVIEW

Soybean

A Vital Crop for Louisiana

Donald J. Boquet

The history of the soybean crop in Louisiana is rather brief compared with cotton, sugarcane, rice and corn, which have been grown in the state for several hundred years. Louisiana has had extensive soybean production only since the 1970s. The story of the Louisiana soybean industry is one of initial success followed by decline and then a re-emerging industry. The initial production years were characterized by rapidly expanding acreage and profitable yields with few yield-limiting production problems. Soybean acreage went from virtually none to more than 3.4 million acres in less than 10 years, making soybean Louisiana's most economically important row crop. Producing soybeans continuously on the same acreage in a mono-cropping production system to the exclusion of crop rotations was not sustainable, however. Today, we recognize that among the soybean producing states, Louisiana, because of its subtropical climate and unpredictable weather systems, faces the greatest challenge to a competitive and profitable soybean industry. The primary problems include a diversity of pests (diseases, weeds, insects and nematodes) and reduced soil productivity (low fertility, pH and organic matter) that affect yield and grain quality. Much too often, poor quality grain resulting from insects, pathogens and adverse weather reduces value and limits marketability, sometimes even preventing sale of grain. For Louisiana farmers, profitable soybean production is a combination of agronomic, economic and pest management challenges during each growing season.

Within 10 years of soybean expansion during the 1970s and 1980s, pest and soil fertility problems became severely yield-limiting. Most of the acres converted from other crops, pastures and forests to soybean production experienced low productivity. As quickly as acreage had expanded, it retracted as farmers responded to low yields and reduced profits. Planted acreages dropped from 3 million to 1 million in 1999, and the low point for soybean production in Louisiana was reached in 2001 when planted acreage was only 640,000 acres. However, 2001 was also a landmark year because it was the first year that soybean yield averaged more than 30 bushels per acre (up from 21 bushels per acre produced in 1981). Yields have not fallen below this level since that year. A second breakthrough for yield was attained only 10 years later in 2010 with production of a statewide record yield above 40 bushels per acre. Soybean grain sales were estimated at $568 million in gross income to Louisiana farmers in 2010.

The revival of the Louisiana soybean industry was no accident. It occurred because of a better understanding of agronomic and plant protection practices needed to increase productivity. Concurrent with the development of the state's soybean industry during the past 40 years was the development of extensive soybean research and extension programs to support the industry, initially within land-grant universities and the U.S. Department of Agriculture. More recently, these efforts have been increased among private seed breeding companies. As the research articles in this issue of *Louisiana Agriculture* demonstrate, many of the potential impediments that limit productivity or profitability of soybean from Louisiana farms are the focus of studies by LSU AgCenter scientists. It is appropriate to note that 90 percent of the AgCenter's soybean research projects receive partial funding from the check-off dollars contributed from, and managed by, soybean farmers, thus ensuring that research is targeted to specific areas. This issue highlights many of the ongoing studies from AgCenter soybean research and extension programs. These studies concentrate on the many problems limiting production. These study result in new technologies, varieties, agronomic and pest management practices needed to grow profitable soybeans, which, in recent years, has resulted in a re-emergence of the Louisiana soybean industry. These articles illustrate the progress that has been made through comprehensive research programs that continue to support the progressive development of a Louisiana soybean industry that is competitive and profitable.

Successful soybean production begins with the availability of environmentally-adapted, high-yielding varieties. The varieties grown during the initial 30 years of the Louisiana soybean industry through 1995 were developed in the USDA and land-grant university breeding programs. During the 1970s and 1980s, the LSU AgCenter breeding program released several varieties specifically suited for producing high yield on Louisiana soils. Today, however, the AgCenter breeding program is focused, like other university breeding efforts, on introducing genetic traits for improved oil quality, resistance to diseases and pests, and maintaining yields in adverse environments. Soybean plants are being developed for production under extreme adversity from both biotic and abioitic causes and with greater utility to meet the needs of a growing world population. Complementary to variety development, the AgCenter supports a comprehensive variety testing program that evaluates more than 200 varieties on seven soil types annually. The AgCenter additionally supports an on-farm variety evaluation and verification program that extends directly into many parishes, which helps to further ensure that growers across the state have information to select the best possible varieties and practices to maximize economic returns.

Photo by John Wozniak

Donald J. Boquet, Professor of Agronomy and Jack and Henrietta Jones Endowed Professor, Macon Ridge Research Station, Winnsboro, La.

To take advantage of the yield potential of adapted varieties, field management practices are constantly evaluated to determine the most effective means of integrating best management practices in a holistic approach to maximize the beneficial effects of agronomic and pest management inputs but, very importantly, minimize any harmful effects on the environment. AgCenter scientists have established formal collaborations to ensure that crop protection and soil management programs are not only effective, but also safe for the environment. In this issue of *Louisiana Agriculture*, for example, recently completed research on the green plant malady is described – a crop dysfunction that has been perplexing producers in Louisiana for many years and, more recently, has spread throughout Midsouth soybean fields. Through the efforts of an interdisciplinary team of AgCenter scientists, this malady was thoroughly described and many of the multifaceted causes identified. Farmers now have the information needed to manage and usually avoid losses from this significant production problem. Optimal management strategies also continue to be developed for native insect pests and for newly introduced species. The red-banded stink bug has been of special concern for its feeding habits that devastate seed quality and contribute to the green plant malady.

Yield losses from weed competition are a serious constraint to profitable soybean production in Louisiana. Herbicides are the only economical means of controlling the multitude of weed species in soybean fields. Without effective herbicides soybeans cannot be grown. Weed management has recently become even more of a critical concern with the development of weeds resistant to many herbicides used in Louisiana row crops. The extent of this serious problem and the approaches being taken to minimize herbicide resistance are covered in articles in this issue. Effective weed control measures and weed resistance to herbicides will always be a major concern of soybean producers, requiring continuing research because weeds will continue to evolve mechanisms of resistance in response to whatever control systems are used.

Photo by John Wozniak

With production of a statewide record yield above 40 bushels per acre in 2010, soybean sales were estimated at $568 million in gross income to Louisiana farmers.

Producing high quality grain that is acceptable for processing into quality products for animal and human consumption – and can, therefore, be marketed without discounts – is the goal of soybean farmers. Achieving the goal of producing high quality grain and preserving that quality through harvesting and marketing is often difficult at best and sometimes is simply not possible under Louisiana weather conditions. Seed quality research initiated in 2010 with funding from the Louisiana Soybean and Grain Research and Promotion Board will help to mitigate some of these quality losses. Variety selection, thorough disease and insect control and timely application of harvest aids, when their use is dictated by environmental conditions, can each improve seed quality. Used together they will provide the greatest probability for maintaining seed quality under the prevailing climatic conditions in a given year.

Along with higher production of quality grain, research continues on new product development. Several articles in this issue describe ongoing research by LSU AgCenter scientists to expand functionality of the soybean by developing methods to extract and use bioactive components of both oil and protein. These methods add new uses that can be healthy additions to the diets of expanding world populations and add to the economic value of the soybean crop in Louisiana.

Louisiana soybean acreage may not, and probably should not, again attain the 3.1 million acre levels grown in the early 1980s. Such large acreages in one crop do not allow for crop rotation practices that are needed to maintain productivity. Sensible use of appropriate practices and technology, however, allow soybeans to once again be the largest acreage crop in the state. With increases in yield and quality, fostered by the research and extension programs in the LSU AgCenter, soybeans will likely remain one of the foremost agronomic crops in Louisiana. ■

Harvest Aid

An Important Component of Soybean Production Systems

James L. Griffin and Joseph M. Boudreaux

Photo by James L. Griffin

Soybeans in the background and on the side are the same variety planted at the same time. Soybeans received a Gramoxone Inteon application at 1 pint per acre at 50% average seed moisture and are ready to harvest. Gramoxone not only desiccates leaves but also can help dry down stems.

Harvest aids are herbicides applied to the crop late in the growing season to dessicate leaves and accelerate plant drying. This can result in earlier harvest and improved crop harvest efficiency and seed quality. Because soybean seed fill is dependent on the presence of soybean leaves, timing of harvest aid application is critical. If applied too early before all of the seed on the soybean plant has sufficiently matured, seed weight and yield can be reduced.

The following study was conducted to determine the precise timing for application of harvest aid – in this case paraquat sold as Gramaxone Inteon – to soybeans in Louisiana. Soybeans grown in Louisiana are of two types, indeterminate and determinate. For indeterminate soybeans, flowering and seed set begin in the lower portion of the plant and proceed upward; terminal buds continue growing several weeks after flowering begins. There can be considerable difference in seed maturity on the plant with bottom seed reaching maturity first. With the variation in seed maturation, indeterminate soybeans tend to retain leaf material, and stems remain green later into the growing season. In contrast, for determinate soybeans flowering and seed set are initiated in the middle portion of the plant and proceed toward the top and bottom; terminal bud growth ceases when flowering begins. While there may be some slight difference in seed maturity on the plant, most seed mature at the same time.

James L. Griffin, Lee Mason LSU Alumni Association Professor; and Joseph M. Boudreaux, former Research Associate, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.

The label for Gramoxone Inteon states that application to indeterminate soybean varieties should be made when at least 65 percent of the seed pods have reached a mature brown color or when seed moisture is 30 percent or less. For determinate varieties, paraquat should be applied when plants are mature, i.e., beans are fully developed, half of the leaves have dropped, and remaining leaves are yellowing. The label also states that soybeans should not be harvested earlier than 15 days after application. Where morningglory vines are present, 15 days may be needed to kill plants. For both soybean types the goal would be to apply Gramoxone Inteon as early as possible to expedite harvest but not too early before all seed on the soybean plant have reached maximum dry weight (physiological maturity), when yield loss can occur.

The Study

Indeterminate (Asgrow 4403RR) and determinate (Asgrow 5903RR and Asgrow 6202RR) soybeans were treated with Gramoxone Inteon at 1 pint per acre (maximum label rate). Applications were made when moisture content of seed collected from pods at the four uppermost nodes of plants averaged 60 percent, 50 percent, 40 percent, 30 percent and 20 percent (plus or minus 2 percent). To determine seed moisture, pods were hand shelled and seed were weighed, oven-dried and re-weighed to calculate average moisture percentage.

For the indeterminate variety, Gramoxone Inteon application at 60 percent average seed moisture reduced yield 10 bushels per acre compared with the nontreated (Figure 1A). At this timing, leaves had not begun to yellow and pods were green. At 50 percent average seed moisture, soybean yield was 60 bushels per acre and was not negatively affected compared with the nontreated. Soybeans were harvested seven and 10 days after application depending on year and around 14 days before the nontreated. When application of Gramoxone Inteon was delayed until 40 percent average seed moisture or less, yield was equal to the nontreated and soybeans were harvested around nine days earlier than the nontreated.

For the determinate variety, Asgrow 5903RR, Gramoxone Inteon application at 60 percent average seed moisture reduced yield 13 bushels per acre compared with the nontreated (Figure 1B). Application at 50 percent average seed moisture reduced yield 9 bushels per acre. At 40 percent average seed moisture or less, soybean yield was 59 to 61 bushels per acre and was equal to the nontreated. Soybeans treated at 40 percent seed moisture were harvested 12 and 14 days after application, depending on year, and around seven days before the nontreated. For the determinate variety, Asgrow 6202RR, Gramoxone Inteon application at 60 percent seed moisture reduced yield 11 bushels per acre compared with the nontreated (Figure 1C). When application was delayed until 40 percent average seed moisture or less, soybean yield was 57 to 58 bushels per acre and was equal to the nontreated. Soybeans treated at 40 percent seed moisture were harvested seven days after application and around 12 days earlier than the nontreated. For both indeterminate and determinate soybean varieties, reductions in yield were accompanied by reduced seed weight.

Soybean yield was not negatively affected when Gramoxone Inteon was applied to the indeterminate variety at 50 percent average seed moisture and to the indeterminate varieties at 40 percent average seed moisture. The difference in response was attributed to where flowering and seed set is initiated on the plant and the effect on seed maturity. For the indeterminate variety the most immature seed would be present in the top of the plant. In contrast, for determinate soybean, the most immature seed would be present in both the top and bottom of the plant.

It is not practical that growers determine application timing for a harvest aid by collecting and drying seed to quantify moisture. Using percentage leaf drop or percentage of pods that have reached mature brown color is not the best indicator for harvest aid timing. Rather, harvest aid timing should be determined based on close observation of seed within the pods.

Procedure to Determine When to Apply Harvest Aid to Soybeans

- Begin looking closely at soybean plants when yellowing of leaves is first observed.
- Collect pods from the top four nodes of plants at random across the field.
- Open pods and look for separation of beans from the white membrane of the pod wall. Seed should be easy to shell from the pods.
- If separation of beans from the pod wall has occurred for all pods collected, then all seed on the plant have reached maximum dry weight. It is now safe to remove leaves without affecting seed weight.
- At this time leaves have begun to yellow, and some leaves may have dropped. This can vary greatly depending on variety and environmental conditions. Also, some of the pods on the lower portion of plants have begun to turn yellow.

If after opening the pods not all beans easily separate from the pod wall, application of harvest aid will result in some yield loss because of reduced seed weight, and the effect will be greater for determinate than for indeterminate varieties.

In recent years, there has been an increased incidence of the “green plant malady” where soybean plants retain leaves, and stems remain green after soybean seed have reached harvest maturity. Application of Gramoxone Inteon has decreased green leaf retention, reduced percentage green stems and seed moisture of harvested soybean, and promoted earlier harvest. ■

Photos by James L. Griffin

Pods and shelled seed collected from the top portion of soybean plants. Notice the bright green color of pods and seed and the range in seed size. Gramoxone Inteon application at this stage will result in significant loss in seed weight and yield.

Pods and shelled seed collected from the top portion of soybean plants. Notice that the pods are beginning to yellow and also that the white membrane is still attached to the some of the seed. Within 10 days all of the seed inside the pods will be separated from the white membrane, and Gramoxone Inteon can be applied without negatively affecting seed weight or yield.

Figure 1. Yield of indeterminate and determinate soybeans as affected by Gramoxone Inteon applied as a harvest aid based on average seed moisture. Data averaged over two years.

Figure 1A.
Asgrow 4403RR Indeterminate MG IV Soybean

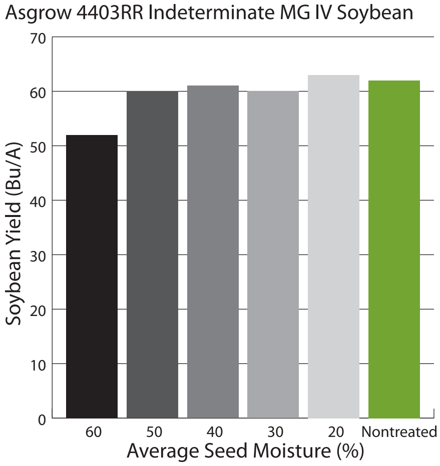


Figure 1B.
Asgrow 5903RR Determinate MG V Soybean

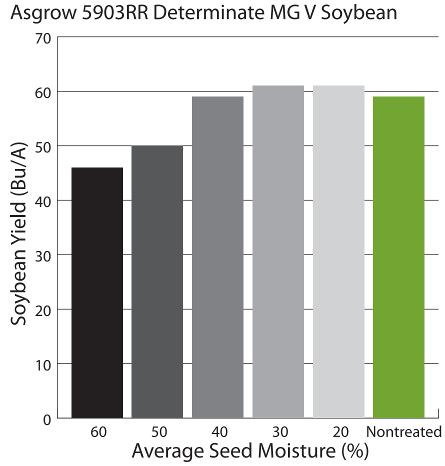
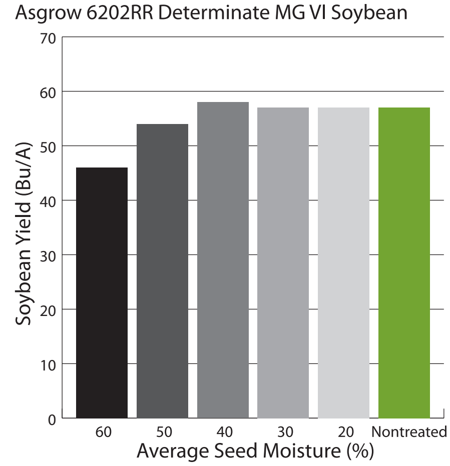


Figure 1C.
Asgrow 6202RR Determinate MG VI Soybean



Soybean Disease Management

Boyd Padgett, Ray Schneider and Clayton A. Hollier

Soybeans are plagued by numerous diseases affecting the leaves, stems, pods and roots. Diseases of major concern are Cercospora foliar blight, purple seed stain, aerial blight, soybean rust, pod and stem blight, and anthracnose. Diseases that occur less frequently are downy mildew, bacterial pustule, Phytophthora rot, frogeye leaf spot, red crown rot and stem canker. If not properly managed, some of these diseases can reduce yields and seed quality. Losses to diseases in Louisiana soybeans were estimated at 13.5 percent in 2009 and 5.6 percent in 2010.

An effective disease management strategy consists of disease identification, production practices, genetic resistance and fungicide use. Proper disease identification is crucial for effective management. This will determine the production practices to be implemented, the varieties to select and the choice and timing of fungicides.

Each year LSU AgCenter scientists conduct research to develop and improve disease management strategies and provide unbiased information to Louisiana producers. Research is conducted on research stations and in producer fields located strategically in the state. Programs target identifying and deploying genetic resistance in soybean varieties, evaluating fungicides for efficacy and monitoring them for resistance, disease epidemiology, and evaluating the effects of production practices on disease development. LSU AgCenter scientists and other professionals also monitor Louisiana soybean production regions for new diseases.

Boyd Padgett, Professor, Macon Ridge Research Station, Winnsboro, La.; Ray Schneider, Professor, and Clayton A. Hollier, Professor, Department of Plant Pathology & Crop Physiology, LSU AgCenter, Baton Rouge, La.

Photo by Craig Gautreaux

Boyd Padget in his lab at the Macon Ridge Research Station.

Disease identification and development

Seedling disease can be caused by a number of soil-borne fungi (species of *Rhizoctonia*, *Fusarium*, *Pythium*, *Phytophthora*). Symptoms include pre-emergent seed rot and post-emergent damping-off. *Pythium* and *Phytophthora* prefer wet soils and cause a wet rot. *Pythium* usually develops best when soil temperatures are cool; however, *Phytophthora* develops best when soil temperatures are warm. *Rhizoctonia solani* develops best when soil temperatures are warm, and infected plants usually have a dry reddish-brown lesion at the base of the stem.

Cercospora blight/purple seed stain is the No. 1 soybean disease in Louisiana. The disease is caused by the fungus *Cercospora kikuchii*. The fungus can infect seedlings and either cause plant death or remain latent. Foliar symptoms of this disease are usually not evident until soybeans are in the mid- to late reproductive stages of growth. Initial symptoms are small, chocolate-brown lesions on the leaf stems near the leaflet. As the disease progresses, foliar symptoms are expressed as a reddish-brown to tan discoloration on the upper leaf surface in the upper canopy. Leaves have a leathery appearance. The fungus can emit spores in older lesions. The spore masses resemble ashes. Advanced stages of this disease result in premature defoliation, discolored pods and reduced seed quality. The seed phase of this disease is evidenced by purple-stained seed at harvest.

Seedling infection is favored by moderate temperatures (70 to 80 degrees Fahrenheit) and extended periods of leaf wetness (up to 16 hours). However, stem and leaf symptoms during late reproductive growth stages, including defoliation, are favored by hot, dry conditions. The pathogen may be seedborne and survives on plant debris in the soil. The fungus also has been isolated from some weeds.

Aerial blight can spread rapidly in soybeans if not properly managed. This disease is caused by the fungus *Rhizoctonia solani* and favors warm, overcast days and extended periods of leaf wetness. This is the same fungus that causes sheath blight in rice. Initial symptoms appear as water-soaked, greasy blotches on leaves (usually in the lower to mid-canopy). As the disease progresses, white, cottony fungal fibers may cause adjacent leaflets to adhere together. If favorable conditions persist, the leaves become brown and blighted, and pods may have reddish-brown lesions. If the disease continues to progress, pods may be aborted. The disease is usually evident during early reproductive stages of growth and later. The potential for risk is increased when soybeans are rotated with rice. This disease can spread rapidly within the crop and should be managed immediately upon detection if the crop is in the late vegetative or reproductive growth stages.

Frogeye leaf spot is caused by the fungus *Cercospora sojina*. Symptoms are found predominately on the leaves but may also appear on the leaf stems, stems and pods. Initially, small, chocolate-brown spots can be found on the leaflets. If the disease continues to develop, mature lesions have light brown to gray centers with reddish-brown margins. Stem lesions are rare and are elliptical with red centers and dark brown to black margins. Pod lesions are circular to elliptical, sunken and light gray to brown. Disease development favors warm, humid weather. The pathogen can survive on seeds and in infected plant debris.

Soybean rust is caused by the fungus *Phakopsora pachyrhizi*. Symptoms begin in the lower canopy as small, brown-to-tan, raised pustules (volcano-like) on the lower leaf surface. Spores produced in these pustules resemble grains of sand and are tan when young. Older spores are darker in color. As the disease progresses, pustules may merge into blighted leaflets, causing them to defoliate. Symptoms are usually evident when soybeans are in the mid- to late reproductive growth stages. Pustules can also be present on leaf stems and pods when the disease is severe. Kudzu is another host for this fungus. The disease develops rapidly when temperatures are between 59 and 77 degrees Fahrenheit and when leaves remain wet for six to 10 hours.

Downy mildew is caused by the fungus *Peronospora manshurica*. Currently, this disease is not a major threat to soybeans produced in Louisiana. Symptoms may be confused with those produced by soybean rust. Symptoms begin as small, pale green-to-yellow spots on the up-

A collection of photos of soybean diseases is included in the online version of Louisiana Agriculture. Go to www.LSUAgCenter.com and click on Louisiana Agriculture Magazine.

per leaf surface. Older lesions or spots may turn gray to dark brown. When the disease is active, grayish tufts of fungal mycelium (similar to dryer lint) can be found on the underside of the leaf opposite the yellow spot. The disease develops rapidly when temperatures are between 50 and 77 degrees Fahrenheit during extended periods of high relative humidity.

Bacterial pustule is caused by the bacterium *Xanthomonas axonopodis* pv. *glycines*. Symptoms of this disease are similar to soybean rust. Although present in most years, this is not a major disease of Louisiana soybeans. Symptoms begin as small, pale green, water-soaked spots with elevated centers on the upper and lower leaf surfaces. As the spots mature, they turn brown with elevated, volcano-like pustules on the lower leaf surface and are easily confused with rust. Careful examination with a dissecting microscope or a 20X hand lens is required to distinguish between these two diseases. Pustules are dry in appearance and may be found on pods in susceptible varieties.

Disease development favors temperatures between 85 and 90 degrees Fahrenheit and wet weather. The bacterium may be seedborne. It survives on surface crop residue, on wheat roots and in weed hosts such as red-vine. The bacteria may be dispersed by splashing water or wind-blown rain.

Pod and stem blight occur most frequently on the stems and pods. The disease is caused by the fungus *Diaporthe phaseolorum* var. *sojae*. Infection may occur early in the season; however, signs of the disease are not evident until late in the season. Pycnidia (fruiting bodies that resemble black specks) occur in rows on the stems and pods. If favorable conditions persist, seed quality will be compromised. This disease favors warm, wet weather. The fungus overwinters in crop residue or infected seed.

Anthracnose is caused by the fungus *Colletotrichum truncatum*. Early infections by the fungus can result in pre- and postemergence damping-off. Foliar symptoms include leaf stem cankers, leaf rolling, vein death and premature defo-

Photo by Bruce Schultz

Planting soybeans.

liation. The fungus can produce acervulli (fruiting bodies that resemble black specks) on the stems and pods. These bodies occur randomly on the stems and not in rows as in pod and stem blight. If the disease continues to develop on the pods, seed quality will be compromised.

The disease favors periods of high relative humidity. Infection occurs throughout the growing season. The fungus overwinters in crop debris and infected seed.

Charcoal rot is caused by the fungus *Macrophomina phaseolina*. Infected seed may not germinate, or seedlings may die soon after emergence. Symptoms from plants with latent infections or mid- to late-season infections die prematurely during hot, dry weather. Symptoms are associated with dry spots (sandy areas) in the field. The roots and lower stems deteriorate. The epidermal and sub-epidermal tissue will be silvery in color and dotted with black pepper-like sclerotia (survival structures).

Disease development favors hot, dry weather (82 to 95 degrees). The fungus can survive in the seed coat, in host residue or in the soil.

Red crown rot is caused by the fungus *Calonectria ilicicola*. Root infections may occur soon after planting, but initial symptoms are usually not evident until soybeans are in mid- to late reproductive growth stages. Roots become black with rotted segments, and the base of the stem at the soil line may be covered with brick-red reproductive structures (usually most evident during periods of high soil moisture). Foliar symptoms are characterized by interveinal yellow or brown blotches.

Moderate temperature and wet soil conditions at planting promote disease development. Maximum root infections occur when soil temperatures are 77 to 86 degrees. The fungus may overwinter in the soil and in infested plant debris on and in the soil.

Production practices, genetic resistance and fungicides

A healthy plant is the first step toward optimizing yields and preventing disease. These production practices can be used to manage many diseases.

- Plant when conditions favor rapid germination and seedling establishment. This recommendation is supported by AgCenter planting date studies conducted in 2009 and 2010.
- Improve drainage within the field. This will help reduce the risk of soilborne disease such as phytophthora rot, pythium seedling disease and red crown rot.
- Promote air movement within the canopy to reduce periods of leaf wetness and lessen the risk from some foliar diseases.
- When possible, genetic resistance should be the foundation of any disease-management strategy. Always use high-yielding, disease-resistant varieties when available. Every year, AgCenter scientists evaluate commercial varieties on several research stations. Disease reactions for each variety can be found on the LSU AgCenter soybean website.
- When genetic resistance is not available, fungicides can be used for managing diseases. Fungicides are monitored for their performance in experiments conducted on research stations and in producer fields every year. In addition, the effects of single versus multiple applications and application timing also are evaluated. There are several fungicide classes to choose from. The disease present will dictate which class is needed. Three classes of chemistries are available to producers: strobilurins, benzimidazoles and triazoles (Table 1).

In LSU AgCenter tests, the strobilurins have broad-spectrum activity. This class is effective against aerial blight and pod diseases, slightly effective against Cercospora blight and suppressive against soybean rust. Topsin M and TM-85 are moderately effective against Cercospora blight and pod diseases but not effective against soybean rust. Triazole fungicides are used for managing soybean rust, and some evidence suggests they may be effective against Cercospora blight. Some of these fungicides may confer activity against other diseases, but more evaluations are needed to make this determination.

Other factors to consider when making a fungicide application are timing and sprayer setup. Applications should be made when soybeans are between pod-initiation and seed-initiation growth stages. Early applications will provide better efficacy against Cercospora foliar blight, and later applications will provide better efficacy against pod diseases. Ideally, spraying should be done with 15 gallons of solution per acre by ground or 5 gallons of solution per acre by air. For more information concerning soybean disease management, consult your LSU AgCenter county agent or specialist. ■

Table 1. Classes of fungicides and some commercial fungicides in these classes.

Fungicide Class				
Strobilurin	Triazole	Benzimidazole	Fungicide	Disease
X			Headline	CB, FE, AN, PS, AB
X			Quadris	CB, FE, AN, PS, AB
X			Gem RC	CB, FE, AN, PS, AB
X	X		Quilt or Quilt Xcel	SBR, CB, FE, AN, PS, AB
X	X		Stratego or Stratego YLD	SBR, CB, FE, AN, PS, AB
		X	Topsin M / TM-85	CB, FE, AN, PS
	X		Alto	SBR
	X		Domark	SBR
	X		Proline	SBR
	X		Tilt, Bumper	SBR
	X		Topguard	SBR

AB=aerial blight, AN=anthracnose, CB=Cercospora blight/purple seed stain, PS=Pod & stem blight, SBR=soybean rust.

Toward a Disease-Resistant Soybean Variety

J. Blair Buckley

Soybean producers annually face diseases, insects and environmental stresses that affect the yield and quality of their crop. The use of varieties with resistance to specific pests and stresses is generally considered the most cost-effective solution to these problems. The focus of the LSU AgCenter's soybean program is to develop high-yielding varieties with resistance to major Louisiana diseases.

Currently, the disease of most concern to Louisiana soybean producers is Cercospora leaf blight caused by the fungus *Cercospora kikuchii*. The first symptoms of the disease typically occur late in the season as the seeds within the pods approach full size. The leaves in the upper portion of the plants exposed to the sun develop a purplish-bronze appearance. Dark lesions may occur on the leaf stems and on the upper and lower leaf surfaces. The fungal toxin cercosporin is translocated into the leaf and is converted into its toxic form by light. Cercosporin damages the leaf tissue and causes defoliation of upper leaves and the presence of green leaves below the defoliated area. Cercospora leaf blight severity is influenced by temperatures between 82-90 degrees Fahrenheit and high relative humidity. Severe infections can cause substantial yield loss and reduce seed quality. Fungicides have not been highly effective in controlling Cercospora leaf blight.

LSU AgCenter researchers evaluate Cercospora leaf blight resistance in soybean varieties developed in the United States and many other countries. These varieties are grown in the field and rated for Cercospora leaf blight symptoms. Varieties identified as having the least amount of symptoms are crossed with varieties possessing other desirable traits, such as high yield, strong stems and pods that don't open prematurely. The goal is to combine Cercospora leaf blight resistance with these desirable traits into new varieties that possess both.

Soybean flowers contain both male and female parts. Varieties used in crosses are designated as either male or female parents. Crosses are made by the tedious process of taking pollen from a male parent plant and placing it on the female flower part of the designated female parent plant. Seeds from the crosses then are planted to produce a second generation of seed.

The second generation is evaluated for Cercospora leaf blight resistance at the Red River Research Station in Bossier City. Promising plants are selected and advanced for further evaluation. Testing for yield begins in the fourth generation. Advanced-generation breeding lines that continue to perform well for Cercospora leaf blight resistance, yield and other desirable traits are evaluated at additional state and regional locations. Soybean lines that perform well in state and regional trials will be considered for release as varieties.

Soybean breeding lines currently with the greatest Cercospora leaf blight resistance exhibit a few leaf-stem lesions and slight bronzing of upper leaves, but they do not have any apparent yield loss, decrease in seed quality or premature defoliation. Disease symptoms in these lines consistently develop at a later growth stage than in highly susceptible lines.

Research includes studies to determine when the fungus infects the plants. A better understanding of when infection occurs and how symptoms develop in moderately resistant lines compared with highly susceptible soybean varieties will aid the effort to develop Cercospora leaf blight-resistant varieties. Previous research found considerable genetic diversity within the Cercospora leaf blight fungus and that the Louisiana *Cercospora kikuchii* population is significantly different from samples of the fungus collected elsewhere. Knowledge of this variability amount the fungi can be incorporated into the breeding strategy for Cercospora leaf blight resistance.

In addition to breeding for resistance to Cercospora leaf blight, the breeding program is placing some effort on breeding for frogeye leaf spot resistance, drought tolerance and salt tolerance. The general approach for breeding for these traits is somewhat similar to that for Cercospora leaf blight. However, unlike Cercospora leaf blight, there are numerous sources of resistance for frogeye leaf spot and several for salt tolerance. Soybean breeders, however, have made less progress in breeding for drought tolerance.

The continued development of soybean varieties with resistance to diseases and stresses common to Louisiana will provide soybean producers with an economical method of control for these limits to production. ■

J. Blair Buckley, Associate Professor, Red River Research Station, Bossier City, La.

Photo by Mary Ann Van Osdell

J. Blair Buckley at the Red River Station.

Soybean viruses in Louisiana affect yield, seed quality

Rodrigo A. Valverde

The soybean foliage at the left is infected by soybean mosaic and bean pod mottle viruses. On the right is a healthy plant.

Soybean viruses have been shown to cause significant yield losses throughout the soybean-producing areas of the world. In the United States, many different viruses infect soybeans. Viruses, alone or in combination, can cause foliar mosaic, leaf malformations, stunting, seed discolorations and, more important, lower yields. Because insects are the main vectors of plant viruses, the occurrence of viral diseases is often associated with an increase in insect populations.

During 2008 and 2009, soybean leaf samples showing virus-like symptoms were collected from 11 different locations across Louisiana. Samples were tested for the presence of viruses by an enzyme-linked test using blood serum containing antibodies against antigens specific for several known soybean viruses. Results indicated that the two most common viruses in Louisiana are the aphid-transmitted soybean mosaic virus and the beetle-transmitted bean pod mottle virus. These viruses have been shown to cause significant yield losses in other states.

Some plants showing virus-like symptoms did not give positive reactions with the test. Therefore, it is likely that these plants were infected with other viruses for which the test was not used or by soybean viruses that have yet to be described. The effects of bean pod mottle and soybean mosaic on yield depend upon the time of virus infection and the occurrence of mixed infections. In spring 2010, a greenhouse experiment was conducted to determine the effect of bean pod mottle and soybean mosaic, alone and in combination, on soybean yield. The experiment was conducted in the greenhouse rather than in the field to avoid natural spread of the viruses by insect vectors.

Maturity Group IV soybeans were planted in 1-gallon clay pots, and two weeks after emergence, plants were mechanically inoculated with soybean mosaic, bean pod mottle or a mixture of both viruses. Some plants were used as healthy control. Plants were kept in the greenhouse until maturity. Symptoms evaluated throughout plant growth con-

Rodrigo A. Valverde, Professor, Department of Plant Pathology & Crop Physiology, LSU AgCenter, Baton Rouge, La.

Table 1. Soybean viruses detected during 2008-2009 – total positive/total tests.

Parish	Soybean Mosaic	Bean Pod Mottle	Other[a]
Acadia	5/12	3/12	0/12
Allen	1/10	0/10	0/10
Avoyelles	5/15	2/15	1/15
Bossier	5/15	3/15	1/15
Concordia	4/17	2/17	1/17
East Baton Rouge	21/75	4/75	3/75
Iberia	2/10	0/10	0/10
Pointe Coupee	6/50	2/50	1/50
St. Landry	3/12	0/12	0/12
St. Tammany	1/10	2/10	0/10
Tensas	3/15	5/15	0/15
Total Positive/Total Tested	**56/241**	**23/241**	**7/241**

[a]*Other viruses detected include alfalfa mosaic, tobacco ring spot and cucumber mosaic virus.*

Table 2. Results of single and mixed inoculations of soybeans with bean pod mottle and soybean mosaic virus.

	Soybean mosaic	Bean pod mottle	Soybean mosaic + bean pod mottle	Healthy
Plant Height (in.)	25.6	24.6	12.2	27.6
Number of Pods	36	32	15	50
Seed Weight (oz.)	0.31	0.28	0.07	0.44
Percent of yield reduction	26	33	84	0
Plants showing green stem	0/15	5/15	6/15	0/15

Photo by Rodrigo A. Valverde

sisted of foliar mottle, mosaic, malformation and reduced plant growth.

Bean pod mottle alone induced more severe symptoms than soybean mosaic; however, the most severe symptoms were caused by mixed infections of both bean pod mottle and soybean mosaic. The severity of the symptoms was associated with reduced yields. When compared with healthy plants, the average reductions on seed weight ranged between 26-33 percent depending on the virus (Table 2). Simultaneous infections by both viruses resulted in an 84 percent loss in seed weight. Stained seed was common among plants with mixed virus infections. In general, when viral infections occur late in the plant development, the effect on yields is not as severe as when the infections occur earlier in plant development.

Some plants infected with bean pod mottle alone or in combination with soybean mosaic exhibited green stem at maturity; however, not all bean pod mottle-infected plants developed the green stem disorder.

Increased insect activity, lower yields, mottled seed and green stem plants at harvest are indicators of a potential virus disease problem. Foliar symptoms such as mottling and leaf malformation are good indicators of virus infection. Using soybean varieties resistant to these viruses and controlling insect populations are the best approaches to avoid virus problems.

This information will help soybean producers identify management options that reduce losses caused by plant viruses. Moreover, this type information is of great value to personnel conducting evaluations and selections of new soybean varieties for Louisiana. ■

Soybean Rust Sentinel Plot Program

Clayton A. Hollier, Patricia A. Bollich and Boyd Padgett

The Soybean Rust Sentinel Plot Program is designed to monitor the presence and movement of soybean rust in the state. The program was initiated in 2005, the year after soybean rust was detected in Louisiana and surrounding states. The purpose of this program is similar to those programs developed in the rust-infested areas of Africa and South America.

Fifteen soybean sentinel plots (and 20 kudzu locations) are scattered in the soybean growing areas. This provides the rust scout defined areas to monitor weekly. The soybean plots are no less than 2,500 square feet and easily accessible. If possible, plots are planted along tree lines where the microenvironment within the plant canopy is more conducive to rust development than in full sunlight.

Two varieties of soybeans, one each representing maturity groups IV and V, are planted about three weeks prior to the surrounding commercial fields so that more mature plant material is available in the area where soybean rust could develop. Although the rust can develop on any growth stage of soybeans, it is more likely to develop on more mature plants. If soybean rust is found in the sentinel plot, this is a signal to scout surrounding commercial fields. The growth difference in sentinel and commercial fields allows soybean growers time to make decisions concerning the best options for managing soybean rust in their fields.

The soybean rust pathogen is a biotroph, which means it must obtain its energy from living host cells. Therefore, it is dependent on its plant hosts for survival. Development of soybean rust each season varies with the inoculum load and the weather. For example, the winter of 2008-09 was relatively warm allowing soybean rust to overwinter on kudzu, another host of the rust, and increasing the inoculum (causal fungus) load early in the spring of 2009. Soybean rust was observed on soybeans in May that year and continued to develop as the spring and summer weather allowed. By contrast, the winter of 2009-10 was cold with several recordings of temperatures lower than 20 degrees Fahrenheit. The cold air destroyed kudzu, thus reducing the survival of potential overwintering inoculum. The result was a delay in the buildup on the fungus in the spring and summer of 2010, reducing the threat of soybean rust during the 2010 season. Weekly scouting of the soybean sentinel plots revealed the first soybean rust of the season in late September, too late to be a threat to the Louisiana crop.

The potential impact of soybean rust in Louisiana is low most years, but if the right combination of conditions occurs, it could have a major impact on bean yield and quality in the state and provide inoculum to our northern soybean growing neighbors. That fact has been recognized by the Louisiana Soybean and Feed Grains Research and Promotion Board, the North Central Soybean Research Program and United Soybean Board, each of which continues to fund the program.

The Soybean Sentinel Plot Program has been successful in keeping farmers informed of the status of this disease. Even though rust has not developed to the epidemic levels it has in other parts of the world, Louisiana growers can be assured of early notification of potential problems. ■

Clayton A. Hollier, Professor, and Patricia A. Bollich, Scientific Research Technologist, Department of Plant Pathology & Crop Physiology, LSU AgCenter, Baton Rouge, La.; and Boyd Padgett, Professor, Macon Ridge Research Station, Winnsboro, La.

Improving Soybean Seed Quality

Donald J. Boquet, B. Rogers Leonard, Boyd Padgett and Sterling Brooks Blanche

Louisiana farmers often harvest soybeans with a high percentage of damaged seed, resulting in significant marketing discounts. Seed damage is caused by Louisiana's climatic conditions that encourage high levels of diseases and insect infestations in soybean fields. Also, wet weather and water-saturated soils frequently delay harvest, which contributes to the further deterioration of pods and seed in the field. Methods to minimize damage to seed during the growing season and after seed maturity would be of great value to the Louisiana soybean industry.

Seed quality is the highest as soon as crop development is completed and before any weather-related events cause deterioration. Seed quality is a function of initial quality at maturity, which is the cumulative effect of a variety's genetics and exposure to season-long growing conditions including diseases and insects. It's also a function of harvest quality, which includes the effects of field weathering after maturity.

Initial differences in quality are derived from differences in maturity date, the producer's management practices, and the inherent ability of varieties to protect developing seed from diseases such as anthracnose, cercospora/purple seed stain and phomopsis. Resistance to weathering is derived from differences in pod wall structure. Some varieties may have pod walls that are more substantial (physical and chemical attributes) and maintain their integrity longer than other varieties and, therefore, protect seed longer from weathering and, perhaps, from diseases and insect damage. Over time, however, all pods deteriorate and, if wet conditions persist, seed eventually become susceptible to opportunistic fungi and bacteria (Figure 1). A common thought among producers has been that the characteristics of brown pods protect seed better than gray pods, but no research has yet demonstrated this effect.

In 2010, a project partially funded by the Louisiana Soybean and Grain Research and Promotion Board was initiated to identify genetic and environmental factors affecting seed quality and to develop practices to improve seed quality. The objectives are to:

1) Develop a method to evaluate soybean seed quality that relates to state and federal grading standards.

2) Assess differences among varieties in seed quality at maturity and after periods of field weathering.

3) Evaluate the value of fungicides and insecticides at mid and late growth stages for control of seed damaging diseases and insects and improvement of seed quality.

Research Procedures

Despite the fact that seed quality is a principal determinant of the value of soybean grain, there is no standard research method for evaluating seed quality that equates with U.S. Department of Agriculture or state grading standards used for marketing grain. Rather, a numerical rating system developed in the 1940s is occasionally used to assess seed quality differences. The system is a subjective visual rating of 1 through 5, where 1 is excellent quality, 2 is good quality, 3 is fair quality, 4 is poor quality and 5 is very poor seed quality (Figure 1). This is a rapid method for quality assessment that accounts for all visible sources of seed damage, but it is unclear how this system correlates to grading requirements used in marketing grain that also assesses internal seed damage. The two systems will be compared to determine if the subjective 1 to 5 rating has value to researchers and producers or if some other system is needed.

In 2010, the initial year of the project, several field experiments were established to address the project objectives. Two experiments were completed to determine the seed quality benefits from applying combinations of fungicides and insecticides at different times during R2 (early flowering) through R7 (physiological maturity) growth stages. A third experiment evaluated the seed quality of 16 varieties expressing independent genetic and phenotypic traits. The three experiments were planted under a sprinkler irrigation system used to periodically wet the plants to simulate weathering effects on seed after R8 (harvest maturity).

In each experiment, beginning at R8, pod samples were collected at 10-day intervals for 40 days for seed quality evaluation. In addition, the official soybean variety trials at the Macon Ridge Research Station near Winnsboro and the

Figure 1. Starting at upper left, the seed quality is 1, the highest, to 5, the lowest, which is bottom right.

Donald J. Boquet, Professor of Agronomy and Jack and Henrietta Jones Endowed Professor; B. Rogers Leonard, Professor of Entomology and Jack Hamilton Regents Chair in Cotton Production; Boyd Padgett, Professor, Macon Ridge Research Station, Winnsboro, La.; and Sterling Brooks Blanche, Assistant Professor, Dean Lee Research Station, Alexandria, La.

Dean Lee Research Station near Alexandria were used to study variety effects on seed quality. Pods from selected varieties with variable maturity dates and different phenotypic traits were collected at R8 and at 10-day intervals for 40 days after R8 for seed quality evaluation. A total of 72 varieties were sampled – 10 from Maturity Group (MG) 4.0-4.5, 30 from MG 4.6-4.9 and 32 from MG 5. Maturity Group refers to the length of the growing season with lower number groups maturing earlier than higher numbers. Samples were evaluated subjectively with visual ratings and objectively with official grading criteria.

Results

Conditions that usually cause severe seed quality deterioration in Louisiana did not occur in 2010, and soybean seed quality across Louisiana was the best seen in 20 years. Insect infestations were low throughout the summer, and harvest weather was dry, with no extended rainfall events delaying harvest. Seed that remained in the field for 40 days after maturity retained excellent quality. As a result, the 2010 crop incurred almost no discounts for seed damage, which was highly beneficial for producers. The lack of conditions that typically cause extensive seed damage, however, placed limitations on the seed quality research project.

Photo by John Wozniak

Disease and Insect Control. In the two studies to evaluate effects of diseases and insects on seed quality, the nontreated controls had excellent quality both at crop maturity and after 40 days of weathering. Application of insecticides and fungicides for pest control had little effect in improving quality. One important finding of the studies, however, was that the application of water with an overhead sprinkler system to simulate rainfall had limited effectiveness in causing seed deterioration under otherwise dry weather conditions. Pods dried quickly after wetting, not allowing enough seed moisture increase to support growth of pathogens or opportunistic saprophytic organisms. From these results, future studies will require a unique approach to induce seed weathering. Multiple water applications during night time will be needed to create an adverse environment for weathering seed.

Pod color and quality. The color of soybean plants (and pods) results from a combination of the external plant tissue and pubescence colors, both of which can vary from dark brown to gray. Pod and pubescence colors can be shades of brown, tawny, chocolate, tan or gray. The specific combination of tissue and pubescence color imparts the plant/pod color seen at maturity. The color combinations are so numerous a numerical system was developed to describe pod color in which 1 = dark brown, 2 = brown, 3 = light brown, 4 = tan and 5 = gray plants/pods. These numerical designations for pod color allow statistical analyses to determine if there is an effect of pod color on seed quality. These analyses revealed that in 2010, there was no association between pod color and seed quality of varieties. There was, however, a variety effect on quality, with values ranging from an excellent rating of 1.2 to moderately poor rating of 2.9. You can view Table 1 in the online version of the magazine. Go to www.LSUAgCenter.com and then to Louisiana Agriculture Magazine.

This amount of variation in seed quality among varieties, although significant, was less than expected because of growing and harvest conditions. No firm conclusions can be reached about the association between pod color and seed quality until further data is collected under additional plant development and seed weathering conditions.

Varietal resistance to weather damage. One of the project objectives was to determine if there were differences among varieties in tolerance to weather-induced seed damage after crop maturity. Seed quality results of this study are in a table, which is included in the online version of the magazine. (Go to www.LSUAgCenter.com and then to Louisiana Agriculture Magazine.) There were significant differences in seed quality among varieties at maturity and after 40 days of in-field weathering.

Under the prevailing conditions, the differences were small, ranging from excellent to good quality. There were also significant differences among varieties in their ability to resist seed damage after crop maturity, as measured by changes in seed quality ratings between R8 and 40 days after R8. Weathering damage of 40 days duration ranged from no quality change for a single variety to as much as a one point quality loss for another variety.

These results suggest that measurable seed quality differences among varieties exist, but the overall soybean seed quality in 2010 was not representative of usual conditions in Louisiana. These preliminary results do not, therefore, provide information on varietal performance under weather conditions of a normal year when seed damage potential is much higher.

Conclusions. Growing conditions and excellent harvest weather in 2010 combined to create an almost perfect, but rare, scenario for production of excellent quality soybean seed. Under the 2010 conditions, applications of insecticides and fungicides could not improve upon existing excellent seed quality. Even with the overall excellent seed quality, there were significant differences among varieties in quality at maturity and after weathering. Further research under more typical weather conditions is needed to verify that varietal differences are large enough to warrant consideration in making variety selections and to determine which specific plant traits and management practices affect seed quality. ■

Louisiana Soybean Variety Testing Program

Sterling Brooks Blanche, Donald J. Boquet, Sarah Sterling, Dustin L. Harrell, Boyd Padgett, T.K. Udeigwe, Howard P. "Sonny" Viator and Clayton A. Hollier

Photos by Sterling Brooks Blanche

Emerging soybean plants.

The Louisiana Soybean Variety Testing Program plays an important role in the soybean industry in Louisiana. LSU AgCenter researchers conduct the trials annually to evaluate commercial soybean varieties for yield potential, agronomic performance and resistance to diseases. The trials provide Louisiana soybean producers, seed companies and others interested in variety selection with unbiased results on the performance of soybean varieties in the major production regions of Louisiana.

Sterling Brooks Blanche, Assistant Professor and Soybean Variety Testing Coordinator, Dean Lee Research Station, Alexandria, La.; Donald J. Boquet, Professor, Macon Ridge Research Station, Winnsboro, La.; Sarah Sterling, Research Associate, Red River Research Station, Bossier City, La.; Dustin L. Harrell, Assistant Professor, Rice Research Station, Crowley, La.; Boyd Padgett, Professor, Macon Ridge Research Station; T.K. Udeigwe, Assistant Professor, Northeast Research Station, St. Joseph, La.; Howard P. "Sonny" Viator, Professor and Coordinator, Iberia Research Station, Jeanerette, La.; and Clayton A. Hollier, Professor, Department of Plant Pathology & Crop Physiology, LSU AgCenter, Baton Rouge, La.

Importance of the variety trials

One of the most important decisions that soybean producers make is that of variety selection. Planting the best possible variety in each specific situation is a major step toward achieving profitable soybean production. In practice, variety selection is not such an easy task. In 2010, more than 200 commercial varieties and experimental lines were entered into the program. It is difficult to sort through such a large group of varieties, considering that the performance and profitability of soybean varieties can be affected by many factors, including geographic location, soil texture, weather patterns and management practices. Many of the varieties tested in the program are found not to be adapted to Louisiana and, if planted, will produce much lower economic returns compared with top performing varieties. In fact, only a relatively small number of varieties are top performers that consistently yield among the top 10 percent. The program aids producers in this important component of soybean production by "narrowing the field" and providing sound, unbiased information on the yield and agronomic characteristics expected for each of the varieties.

Testing methods

To evaluate the performance of soybean varieties in Louisiana, 18 trials are conducted annually in six locations across the major soybean production regions of the state (See map). The tests are conducted at LSU AgCenter research stations so they can be closely monitored for data collection and to ensure that factors contributing to variation can be minimized. Any factor such as variations in soil texture or insect and weed pressure that occur in the trial can confound the results and arbitrarily affect the rankings of the varieties.

The relative maturities of different soybean varieties can vary greatly. To group soybean varieties of similar maturity, three tests (an early, medium and medium-late variety trial) are planted at each location. All tests are planted in a randomized complete block design with four replications at each location to identify all sources of variation and accurately quantify the differences among varieties. Statistical analyses are performed to aid in interpretation of the results and to discern which varieties are truly superior.

A broad range of information is collected that can help producers understand what to expect from each variety. Yield is

Weeds are controlled using only conventional herbicides so the genetic yield potential of Roundup Ready, Liberty Link and conventional soybean varieties can be accurately compared. Also, no ALS-inhibiting herbicides are used so both STS and non-STS soybean varieties can be compared on common ground.

the most important factor to consider, but other data that should be considered include standability and plant height (yield potential will not be realized if plants fall down), relative maturity group (it is important to know when plants will reach harvest maturity) and disease ratings (producers can select resistant varieties and minimize yield losses and fungicide applications). In recent years, other factors such as seed quality and the degree of plant greenness at maturity have been recorded.

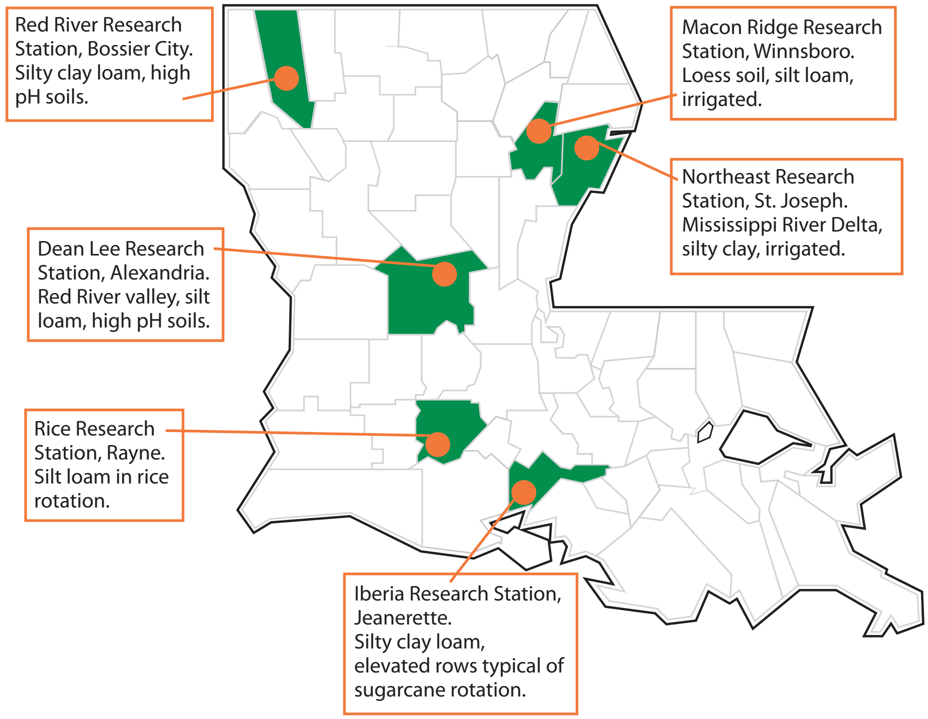
Interpreting the results

Profitable soybean production begins by producing maximum yields, and this is the primary factor in variety selection. However, it is important to realize that a host of factors affect the yield performance of varieties. A single variety is rarely the best variety in all locations and situations. For example, some varieties are adapted to irrigation in northern Louisiana, while others may do well in dryland situations in southern Louisiana. Therefore, variety performance should be evaluated by producers in two ways: 1) averaged across all possible years and locations and 2) in locations similar to the targeted production location.

The performance and consistency of a variety in different years and locations is a strong indicator of future production potential and is the most important criteria used in selection. Data from a single year, while meaningful, is not as good an indicator as performance over multiple years and locations. Because it is unlikely that future growing seasons will be identical to any single location report, selecting a variety that is high-yielding across many environments can increase the probability of success. Consider that for varieties tested for three years, we will have information on their performance in 18 different locations.

Other factors that affect a variety's performance can be evaluated with information from the variety testing program. Varieties differ in their levels of disease resistance. In locations where a specific disease is a perennial problem, producers are advised to raise resistant varieties. Relative maturity is another factor to consider. In most cases, producers spread their risk and coordinate their planting and harvest capabilities by planting varieties from different maturity groups.

Table 1. Test locations used in the Soybean Performance Trials and their characteristics.



More specific information is available for variety selection such as seed quality ratings, variety ratings for green bean syndrome, and resistance to salt damage.

The Soybean Variety Testing Program provides a wealth of information for the Louisiana soybean industry. LSU AgCenter scientists are constantly updating and modifying these trials to provide the maximum benefit to all segments of the soybean industry. Louisiana soybean producers who use the program results for variety selection will greatly increase their chances of planting superior varieties and optimize their yield and profit potential. ■

Acknowledgments
Millie Deloach, Grayson Close, Darrell Franks, John Stapp, Tim Talbot, James Leonards, Ronald Regan, Jacob Fluitt, Al Coco, Jim Hayes and Greg Williams

Photo by Sterling Brooks Blanche

Agronomic information such as maturity and plant height can differ greatly among varieties. It is vital that producers use information from the Louisiana Soybean Variety Trials to understand the agronomic performance of soybean varieties in Louisiana growing conditions.

Seasonal Abundance and Occurrence of the Redbanded Stink Bug in Louisiana Soybeans

Joshua Temple, Jeffrey A. Davis, Jarrod Hardke, Paul Price, Steve Micinski, Colleen Cookson, Arthur Richter and B. Rogers Leonard

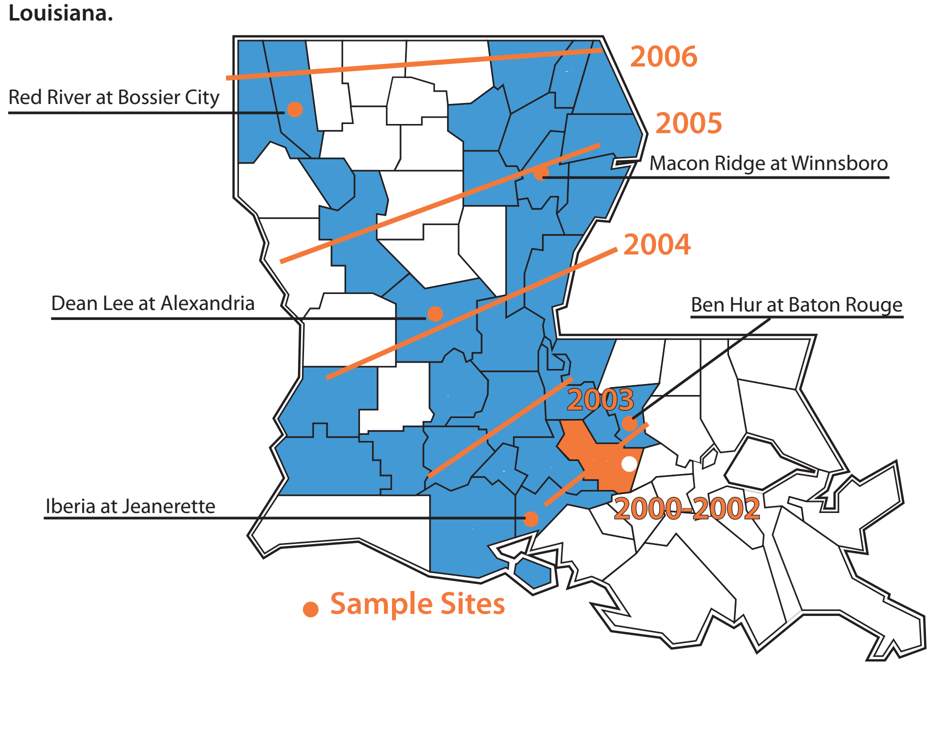
The most yield-limiting and economically important soybean pest across the southern United States is a complex of stink bugs. Historically, the most common species in this complex had been the green stink bug, southern green stink bug and the brown stink bug. However, during the past decade, a new species, the redbanded stink bug, has become more common across Louisiana. This species was first reported in south Louisiana during 2000 by crop consultants and LSU AgCenter extension agents. By 2002, the redbanded stink bug exceeded the stink bug action thresholds and justified using insecticide sprays on a single pest in this complex across many areas of south Louisiana.

It is not clear how or when the redbanded stinkbug became established in Louisiana. This is a neotropical species that ranges from Argentina to the southern United States. This pest has been recognized as a serious soybean pest in South America and was first reported in the United States in the 1960s.

Comprehensive surveys of stink bug pests in Louisiana soybeans have previously reported four common species – the southern green stink bug, green stink bug, brown stink bug and dusky stink bug. Southern green stink bugs have historically represented the highest proportion of the total stink bug complex. Because the redbanded stink bug has become more common and has become established across Louisiana, LSU AgCenter scientists conducted a study to determine the abundance and seasonal occurrence of the redbanded stink bug compared with other common stink bug pests in soybeans.

Surveys of stink bug pests were conducted across Louisiana soybean production regions (Figure 1) from 2008-2010. Soybeans were planted in quarter-acre to half-acre blocks at five locations, representing the state's soybean production areas. Soybeans representing three maturity groups were planted at recommended planting dates in fields on five AgCenter research stations – Ben Hur at Baton Rouge, Dean Lee at Alexandria, Red River at Bossier City, Macon Ridge at Winnsboro and Iberia at Jeanerette. Soybeans were sampled for insects weekly from first flower through physiological maturity using a sweep net to take six replications of 25 sweeps within each maturity group. Each set of sweep-net samples was evaluated for stink bug species and life stage (adult or nymph). Data were summarized by location and year to determine stink bug abundance

Figure 1. The parishes in blue are Louisiana's principal soybean-producing parishes. The orange dots represent the research stations where test plots were planted. The lines represent the northern migration limits of redbanded stink bugs in Louisiana from 2000-2006. The orange parish is Iberville where the redbanded stink bug was first confirmed in Louisiana.



Joshua Temple, Research Associate; Jeffrey A. Davis, Assistant Professor; Jarrod Hardke, Graduate Assistant, Department of Entomology, LSU AgCenter, Baton Rouge, La.; Paul Price, Research Associate, Macon Ridge Research Station, Winnsboro, La.; Steve Micinski, Associate Professor, and Colleen Cookson, Research Associate, Red River Research Station, Bossier City, La.; Arthur Richter, Research Associate, and B. Rogers Leonard, Professor and Jack Hamilton Chair in Cotton Production, Department of Entomology, LSU AgCenter, Baton Rouge, La.

Figure 2. Frequencies of redbanded stink bugs based upon total species composition for each survey site.

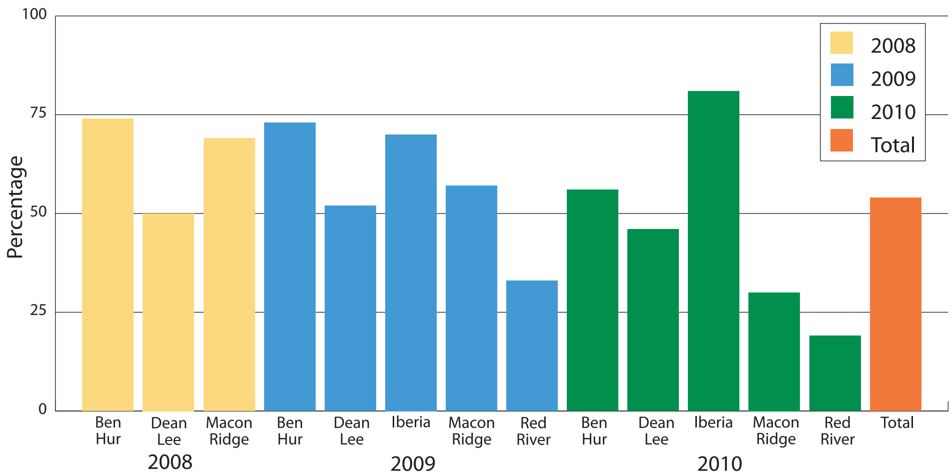
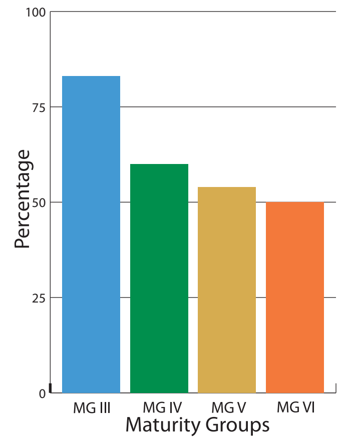


Figure 3. Frequencies of redbanded stink bugs based upon total species composition for each maturity group.



and occurrence for maturity group and plant growth stage.

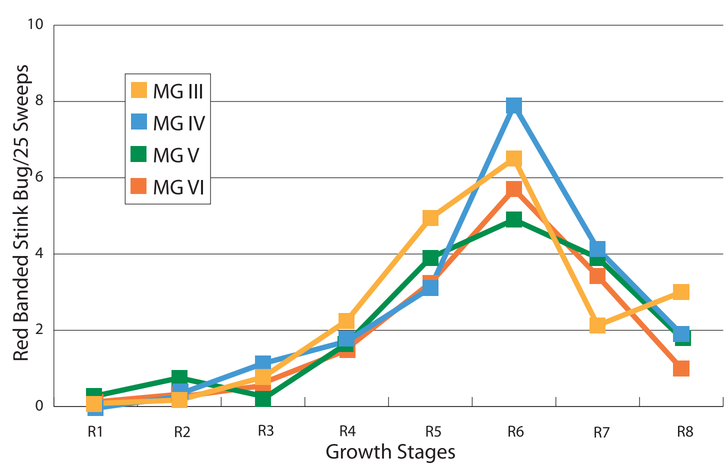
More than 13,000 stink bugs were collected and identified during 2008-2010. The predominant species in the complex were redbanded, southern green, green and brown stink bugs. The most common species of the stink bug collected during this survey was the redbanded stink bug (Figure 2). Previous surveys in the late 1970s and early 1990s did not report redbanded stink bugs in Louisiana soybeans. These new results represent a dramatic shift in species composition of stink bugs. The highest percentage of redbanded stink bugs was collected at the southernmost survey site at the Iberia Research Station in 2010. In contrast, the lowest frequencies of redbanded stink bugs were at the northernmost survey site, the Red River Research Station, in 2010. At the Red River location, the southern green stink bug and the brown stink bug were the most abundant species in 2009 and 2010, respectively.

Redbanded stink bugs prefer to feed on seed and migrate into soybeans during reproductive stages of plant development. Redbanded stink bugs were highest during the R4-R7 soybean growth stages with peak infestations occurring during R6 in all maturity groups (Figure 4). Generally, this pest reached higher peak numbers in early-maturing soybean maturity groups compared with later-maturing maturity groups. The total proportion of redbanded stink bugs relative to other stink bugs ranged from 50 percent to 83 percent (Figure 3) across all matu-

Photo by Joshua Temple

Macon Ridge Station. Delayed crop maturity (green bean syndrome) caused by a stink bug infestation.

Figure 4. Mean redbanded stink bug populations during the reproductive stages of several soybean maturity groups (MG).



Photos by Joshua Temple

Soybeans were sampled with a standard sweep net. Stink bugs such as the two southern green individuals in this net were recorded weekly.

Kyle Fontenot sampling soybeans at the Northeast Station for early-season soybean pests.

rity groups. The percentage of redbanded stink bugs in the total species composition decreased in the later-maturing varieties compared with the early-maturing varieties.

Redbanded stink bugs have been found at action threshold levels (six replications of 25 sweeps) in all soybean-producing parishes (Figure 1). The expansion of this insect's range has not been limited to Louisiana's borders. Redbanded stink bugs are at pest status in soybeans in all states bordering Louisiana and have been reported as far north as Missouri and Tennessee. The redbanded stink bug has been a significant pest only in soybeans. It has been found in other crops at low levels and only when soybeans are not available in adjacent fields. This differs from other stink bugs typically associated with soybeans. The southern green, green and brown stink bugs are more general feeders that reach damaging levels in other Louisiana crops, including corn and cotton. With limited alternative hosts available during the summer, economic levels of redbanded stink bugs can quickly build in soybeans.

In 2010, total stink bugs collected at five samples sites decreased by 60 percent compared to 2009. The reduction in total stink bug numbers has been attributed to lower temperatures during the winter of 2009-10 and drought conditions during the spring of 2010, which reduced the quality of alternative, noncrop hosts. Because the redbanded stink bug has become more prevalent in Louisiana soybeans, the average number of insecticide applications has increased from one or two per season during the late 1990s to three to five per season, with the bulk of those targeting redbanded stink bugs.

Although the redbanded stink bug has become a significant portion of the overall stink bug complex in Louisiana soybeans, it does not appear to be displacing any of the other common pest species. In spite of low numbers of this pest in 2010, other stink bug species exceeded action threshold levels in Louisiana soybeans and required insecticide sprays for management. ■

Photo by Jeffrey A. Davis

Redbanded stink bug eggs.

Continuous Microwave Extraction of Soy Isoflavones for Food Application

Cristina M. Sabliov, Zhimin Xu, Dorin Boldor and Marybeth Lima

Isoflavones are compounds found in soybeans that have powerful antioxidant characteristics and have been shown to prevent cancer and other diseases. Synthetic antioxidants are used as food preservatives to retard rancidity. Because of their superior health benefits, soy isoflavones have been identified as alternative, natural antioxidants to prevent rancidity in food fats.

Microwave-assisted extraction has proved to be a fast, cost-effective, energy-efficient and environmentally friendly process for extracting vegetable oils from various agricultural products. Continuous and batch microwave processing accelerate the extraction process by using heat and pressure to rupture cells. However, the potential of using a continuous, microwave-assisted extraction system for soybean oil on a commercial scale has not been studied in detail.

For photos of the microwave and extraction system and a schematic design, go to the online version of the magazine at www.LSUAgCenter.com.

LSU Ag Center researchers are investigating the extraction of soy isoflavones from soy flour using microwave-assisted extraction and testing the ability of isoflavone extracts to prevent rancidity of fish oil.

To conduct these experiments, a continuous microwave extraction system and a separation system were built. Soy flour and a solvent were mixed together and pumped continuously through the microwave where the mixture was heated to temperatures necessary to extract the oil. Following heating and extracting soybean oil from the flour, the spent flour was separated from the solvent-oil mixture. Then the solvent was removed, and the oil was collected. Oils were extracted using different solvents and exposure times, and the three most prevalent isoflavones were measured.

Of the different solvents tested, ethanol was most effective in extracting total isoflavones. When ethanol was used as a solvent for longer extraction times at 153 degrees Fahrenheit, the yield increased by 330 percent, compared to conventional solvent extraction. Based on the results of the performance tests conducted using the laboratory-scale system, researchers developed and optimized a pilot-scale, microwave-based extraction process. With the pilot-scale system, about 98 percent of the total extractable oil in the soy flour could be recovered at extraction times shorter than six minutes.

The levels of total antioxidant phytochemicals and isoflavones in the defatted soy flour extract and in the soy oil also were compared. The defatted soy flour extract had a much higher level of phenolic compounds and isoflavones than the oil extracted with hexane by a conventional method. The defatted soy flour extract's capabilities in preventing fish oil oxidation were significant. Hexanal, the major rancid substance produced from fat oxidation, was significantly reduced in the presence of the soy flour extract during four days of storage at room temperature. The soy isoflavone extract was capable of stabilizing menhaden oil and preventing oxidation during both heating and room-temperature storage. These results indicate that the extract could significantly retard oxidation of food fats during cooking or storage while also preventing the production of undesirable and toxic oxidation products.

This research shows that continuous microwave extraction is a viable method for efficiently extracting from soy flour and defatted soy flakes total isoflavones with antioxidant properties at higher yields than conventional, solvent-extraction methods. The process also used less solvent and decreased extraction times. The results will be useful to the soybean industry, which now has an alternative, more efficient method for extracting isoflavones from soy products and byproducts. The newly developed method has tremendous potential to revolutionize the way bioactive components are extracted from soybeans on an industrial scale, adding value to the Louisiana soybean industry. ■

Acknowledgment
The Louisiana Soybean and Grain Promotion Board for assistance with funding.

Photo by Tobie Blanchard

Zhimin Xu is using the soy extract as a natural preservative in ground meat.

Cristina M. Sabliov, Associate Professor, Department of Biological & Agricultural Engineering, LSU AgCenter, Baton Rouge, La.; Zhimin Xu, Associate Professor, Department of Food Science, Baton Rouge, La.; Dorin Boldor, Associate Professor, and Marybeth Lima, Cliff & Nancy Spanier Alumni Professor, Department of Biological & Agricultural Engineering.

Battling Herbicide-Resistant Weeds

Daniel O. Stephenson IV, James L. Griffin and Donnie K. Miller

Herbicide resistance is defined by the Weed Science Society of America as the "inherited ability of a weed biotype to survive and reproduce despite exposure to a dose of herbicide that was previously effective on the population."

Herbicide resistance within weed populations has become a tremendous problem in both crop and livestock production systems. Worldwide, 357 herbicide-resistant biotypes have been identified. In the United States, 62 weedy plant species have been documented as herbicide-resistant. In Louisiana in the 1990s, weed resistance was documented in barnyardgrass, common cocklebur, itchgrass and johnsongrass. In 2010, Palmer amaranth and johnsongrass populations were confirmed as resistant to the herbicide glyphosate. Glyphosate is commonly known as Roundup but is sold under various trade names.

The first glyphosate-resistant Palmer amaranth population in Louisiana was found in Concordia Parish. To control 50 percent of the Concordia Parish population required a rate of glyphosate 3.7 times the normal use rate of 32 fluid ounces per acre. In 2011, Palmer amaranth populations in Madison and Tensas parishes were confirmed as glyphosate-resistant. Glyphosate-resistant johnsongrass has been documented in Point Coupee and Rapides parishes. To control 50 percent of the Point Coupee johnsongrass population required a glyphosate rate 10.2 times normal, and the Rapides population required a rate 7.2 times normal.

Development of glyphosate-resistant weeds is due primarily to the use of glyphosate as the sole weed management tool. Applying multiple applications of glyphosate during the crop cycle and over successive years essentially selects for individual plants within a population that are inherently resistant to the herbicide. Over time the weed population shifts to the resistant population, resulting in weed control failures.

In Arkansas, Georgia, Mississippi, Tennessee and other states, crop producers are spending between $75 and $150 per acre for removal (herbicides and hand-hoeing) of glyphosate-resistant Palmer amaranth. Prior to glyphosate-resistant weeds, those producers typically spent $20 to $50 per acre for weed control. Palmer amaranth has become the primary target when budgeting for weed control in a crop. Fortunately, Louisiana crop producers have not encountered the problems with weed resistance that other states are facing. However, unless proper weed management programs are implemented to help mitigate herbicide resistance, LSU AgCenter scientists fear that Louisiana could face a similar fate.

To help mitigate herbicide resistance problems, soil-residual herbicides should be included in a weed-management program. It is critical that fields be weed-free at planting and for at least six weeks after soybean emergence. Not only does this prevent possible germination and emergence of potentially herbicide-resistant weeds, it will lessen physical competition between the growing weeds and the soybean. Various soil-applied herbicides can be applied pre-plant, preemergence and in-crop. Table 1 provides examples of soil-residual herbicides labeled in Louisiana for application prior to or at soybean planting. All of the herbicides when properly activated via rainfall or irrigation have the potential to provide excellent control of grass and broadleaf weeds.

Following the application of a preplant or at-planting, soil-residual herbicide, it would also be important in herbicide-resistance management to co-apply a herbicide with glyphosate that provides foliar or residual control of weeds. Table 2 provides examples of foliar and soil-residual herbicides labeled in Louisiana for use after soybeans have emerged. Even in the presence of a glyphosate-resistant weed population, glyphosate is still effective on many weeds that impair soybean production. These include barnyardgrass, broadleaf signalgrass, browntop millet, hophornbeam copperleaf, morningglory, red rice, sprangletop, sicklepod and velvetleaf. When applying a herbicide prior to glyphosate or when another herbicide is applied with glyphosate, the weed population in the field is exposed to a herbicide mode of action (the specific mechanism and growth process affected by the herbicide) that is different from glyphosate and that is critical to management of herbicide-resistant weeds.

Another option for managing herbicide-resistant weeds is Liberty Link soybeans. Soybean varieties have been developed that are resistant to postemergence applications of the herbicide Ignite, which has a different mode of action than glyphosate. Producers must not apply glyphosate to Liberty Link soybean, or Ignite to Roundup Ready soybeans, or soybean death will occur. All herbicides listed in Tables 1 and 2, except for glyphosate, can be applied alone or in combination with Ignite for weed management in Liberty Link soybeans. Research by LSU AgCenter weed scientists has shown that soil-applied herbicides should be used in Liberty Link systems for maximum weed control. In addition, Ignite should be applied to 2- to 4-inch weeds for maximum utility, indicating the importance of timing in weed management.

When planning a soybean weed management program either in the absence or presence of herbicide-resistant weeds, it is imperative that multiple herbicides with different modes of action be used. Research by LSU AgCenter weed scientists has shown that season-long weed control can be obtained when a soil-residual herbicide is applied at planting and followed by a timely postemergence

Daniel O. Stephenson IV, Assistant Professor, Dean Lee Research and Extension Center, Alexandria, La.; James L. Griffin, Lee F. Mason LSU Alumni Association Professor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.; Donnie K. Miller, John Baker Professor for Excellence in Weed Science, Northeast Research Station, St. Joseph, La.

application of glyphosate along with other herbicides.

Effective weed management programs will also help prevent weeds from producing seed, which could result in a shift over time to weeds more difficult to control. At present, herbicide-resistant weed problems in Louisiana are in the infancy stage compared with neighboring states. With proper planning of weed control programs and herbicide selection, herbicide resistance can be managed, and Louisiana may be able to avoid the serious problems encountered in other states. ■

Table 1. Examples of residual herbicides labeled for use in Louisiana soybeans prior to planting.

Herbicide	Rate/Acre	Application timing	Weeds Controlled	Notes
Authority MTZ	12-18 ounces	At planting	Annual grasses and broadleaf weeds such as morningglory and pigweed	Contains metribuzin. Determine if soybean variety is sensitive to metribuzin prior to use.
Boundary	1.0-2.67 pints	At planting	Annual grasses, pigweed, and numerous other broadleaf weeds	Contains metribuzin. Determine if soybean variety is sensitive to metribuzin prior to use.
Dual Magnum/ others	1.0-1.67 pints	At planting thru 3rd trifoliate	Annual grasses, red rice, nutsedge and small-seeded broadleaves.	Rainfall needed for activation.
Envive or Enlite	3.5 or 2.8 ounces	Prior to or at planting	Broadleaf weeds such as pigweed and some annual grasses	Use Enlite where soil pH is > 7.5.
Metribuzin 75 DF/ others	0.33-1.0 pound	At planting	Broadleaf weeds and some annual grasses	Do not apply to light soils with less than 2 percent organic matter and use high rates on clay soils. Determine if soybean variety is sensitive prior to use.
Prefix	2.0 pints	Before or at planting thru 3rd trifoliate	Annual grasses, pigweed and numerous other broadleaf weeds and nutsedge	Rainfall needed for activation. Postemergence applications may cause temporary injury.
Prowl/Prowl H2O/ others	1.0-3.2 pints	Pre-plant incorporated, pre-plant, or at planting	Annual grasses and johnsongrass from seed	Incorporate 2-3 inches deep or rainfall needed for activation.
Treflan/others	1.0-3.0 pints Higher rates on heavier soils	Pre-plant incorporated	Most annual grasses, johnsongrass from seed	Must be incorporated 2-3 inches deep
Valor SX	2 ounces	Prior to or at planting	Broadleaf weeds such as pigweed	Rainfall at emergence may result in injury, mainly cosmetic.

Table 2. Examples of foliar and soil-residual herbicides labeled for use in Louisiana soybeans after soybean emergence.

Herbicide	Rate/Acre	Application timing	Weeds Controlled	Notes
Dual Magnum/ others	1.0–1.33 pints	Cracking thru 3rd trifoliate	Annual grasses, red rice, nutsedge and small-seeded broadleaves	Rainfall needed for activation. Will not provide foliar control of weeds.
Prefix	2.0 pints	Cracking thru 3rd trifoliate	Annual grasses, pigweed and numerous other broadleaf weeds, and nutsedge	Rainfall needed for activation. Postemergence applications may cause temporary injury.
Sequence	2.5–3.5 pints	Cracking thru 3rd trifoliate	Annual grasses and numerous broadleaf weeds	Contains glyphosate and Dual Magnum. Will not provide foliar control of glyphosate-resistant weeds.
Warrant	3 pints	Emergence thru soybean growth stage R2 (full flowering)	Annual grasses, red rice, nutsedge, and small-seeded broadleaves	Rainfall needed for activation. Will not provide foliar control of weeds. Apply postemergence over-the-top from emergence thru 3rd trifoliate. Apply postemergence-directed between crop row 3rd trifoliate thru R2 (full flowering).
Glyphosate + Select Max or Fusilade or Assure II	Labeled rate + 1.0 pints	Preplant thru soybean harvest	Annual grasses and glyphosate-resistant johnsongrass	Control of glyphosate-resistant johnsongrass may require two applications. Do not use multiple applications in successive years to mitigate possible Select Max, Fusilade or Assure II resistance in johnsongrass.
Ignite 280	22 ounces	Cracking thru 70 days prior to soybean harvest	Broadleaf weeds such as morningglory, hemp sesbania. Poor control of pigweed >4 inch. Poor control of grass weeds.	No more than 65 ounces/acre/year. Research indicates 22 ounces/acre 10 days after soybean emergence followed by 22 ounces/acre 14 days later. Use of preemergence residual herbicides can delay application timing of Ignite if utilized. Glyphosate application will kill Liberty Link soybeans. Ignite application will kill Roundup Ready soybeans.

New Integrated Pest Management Strategies for Stink Bug Control in Louisiana Soybean

Jeffrey A. Davis, Katherine L. Kamminga, Arthur R. Richter and B. Rogers Leonard

Louisiana soybean growers have historically tried to protect their crop from a diverse insect pest complex consisting primarily of stink bugs, Lepidopteran defoliators (green cloverworm, soybean looper and velvetbean caterpillar), three-cornered alfalfa hopper, and bean leaf beetle. Annually, at least one of these pests causes significant problems and is responsible for limiting soybean production by reducing yield. To reduce the economic effects of these pests, growers and consultants scout weekly for insects and apply control measures – insecticides – when these pests reach damaging levels, termed action or economic thresholds.

In the past, the southern green stink bug, the brown stink bug and the green stink bug have had the greatest economic effect on Louisiana soybean producers. In addition to yield losses, stink bug feeding has caused losses in soybean quality and oil content, reduced germination and caused delayed maturity, a syndrome by which the plants retain green leaves, green stems or green pods when they reach maturity. This results in delayed harvest and decreased seed quality.

In 2000, Louisiana had a new stink bug pest arrive – the redbanded stink bug. Before 2000, the redbanded stink bug had never been an economic threat to U.S. agriculture and had been found only in Florida, Georgia and South Carolina. Since its arrival in 2000, the redbanded stink bug has rapidly spread across the state, reaching all soybean growing areas by 2006. It is now the dominant stink bug species in Louisiana soybeans.

What makes the redbanded stink bug such an important soybean pest is its damage potential. Preliminary data from caged experiments indicate the redbanded stink bug is an aggressive soybean feeder, damaging 41 percent of seeds and reducing seed weight by 33 percent within 72 hours. Current action thresholds for stink bugs in most states are nine per 25 sweeps. Because the redbanded stink bug appears to colonize soybean quickly and to reproduce faster than other stink bug species, the current threshold for the redbanded stink bug in Louisiana is six insects per 25 sweeps. In experiments conducted in Louisiana in 2009, controlling the redbanded stink bug at the old threshold of nine per 25 sweeps resulted in 50 percent of the seed being damaged.

Historically, stink bugs have been controlled effectively through insecticides. Unfortunately, the redbanded stink bug is less susceptible to products available for stink bug control on soybeans, and consequently, insecticide applications have significantly increased. LSU AgCenter-recommended guidelines for soybean production include a minimum of three insecticide applications. Preliminary research indicates that even when the insecticide acephate was applied for redbanded stink bug control starting at the full-pod stage, four to six applications were needed to significantly reduce yield loss. Because the primary line of defense against this pest is multiple insecticide applications and a minimum of

Photo by Bruce Schultz

Redbanded stink bug.

Jeffrey A. Davis, Assistant Professor, Department of Entomology, LSU AgCenter, Baton Rouge, La.; Katherine L. Kamminga, Postdoctoral Research Scholar, North Carolina State University Center for Integrated Pest Management, Raleigh, N.C.; Arthur R. Richter, Research Associate, Department of Entomology; and B. Rogers Leonard, Professor of Entomology and J. Hamilton Regents Chair in Cotton Production, Macon Ridge Research Station, Winnsboro, La.

Figure 1. Redbanded stink bug densities from R5 to R7 (Cumulative Stink Bug Days) on J. White farm in Tensas Parish, 2008.

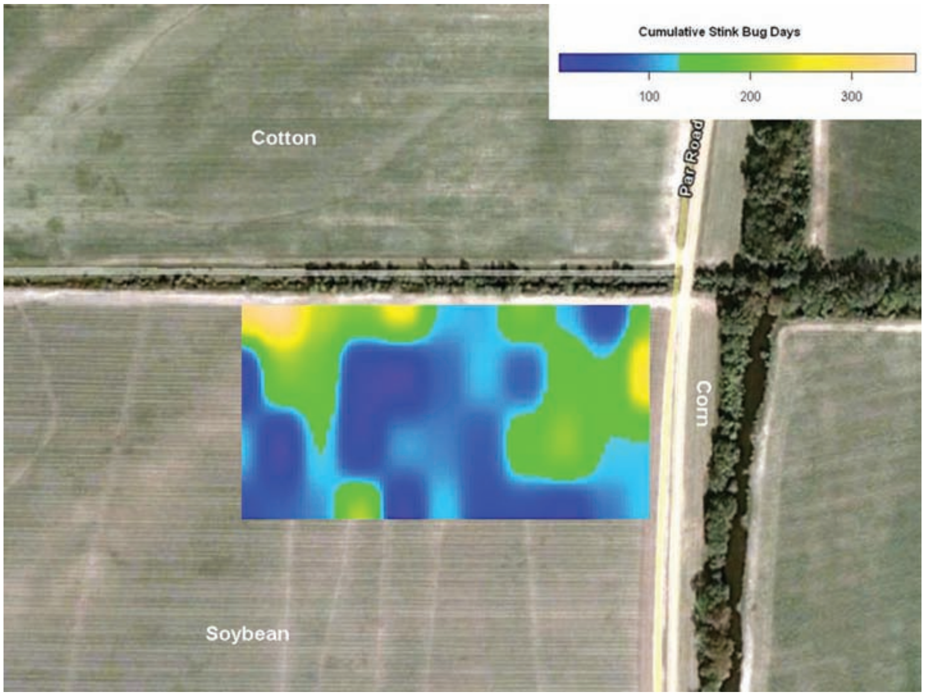


Photo by Jeffrey A. Davis

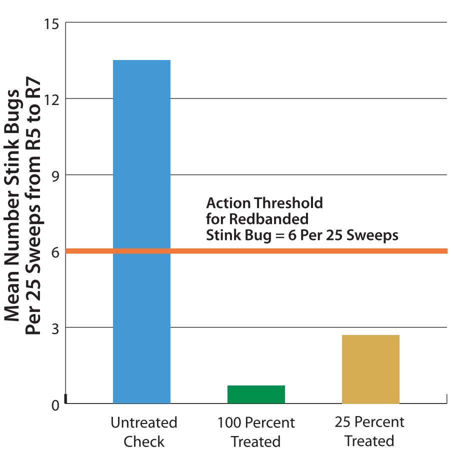
three applications are being applied, resistance to insecticides is inevitable.

In short, Louisiana soybean growers need new management tactics to combat changing stink bug populations without destabilizing the system further with insecticide use. An effective integrated pest management program will be necessary to reduce stink bug effects while increasing productivity and reducing reliance on insecticides. To achieve this, alternative strategies need to be used to reduce the number of insecticide applications.

Field colonization behavior of many stink bugs is known to be concentrated. However, for the redbanded stink bug, specific field distributions and densities are not known. If this pest is concentrated within field margins, site-specific targeting of insecticide applications is possible. This could reduce pesticide applications, saving growers money while conserving natural enemies.

The first step in the experiment was to identify redbanded stink bug population densities and distributions on grower farms. LSU AgCenter research scientists, working in conjunction with their extension counterparts and Louisiana soybean producers, mapped stink bug population densities using handheld GPS devices. Then, conducting spatial analysis with GPS, researchers determined that the redbanded stink bug is concentrated along field edges (Figure 1). The distance from a treeline significantly influenced stink bug field colonization. Field edges that are 50 feet or less from a tree line are 23 to 79 times more likely to have significant stink bug pressure. Thus, fields closest to tree lots, fence rows or conservation areas have greater chances of stink bug infestations.

Figure 2. Perimeter insecticide applications keep stink bug numbers below the action threshold.



The next step in reducing insecticide applications for the redbanded stink bug was to use an attractant to concentrate stink bugs and thus slow field colonization and further concentrate stink bugs for site-specific targeting. Researchers at Virginia Tech found that spinosad acted as an attractant for the brown stink bug. LSU AgCenter scientists conducted laboratory experiments to determine if spinosad attracted the southern green stink bug and the redbanded stink bug. Redbanded stink bug males were attracted to spinosad, and red-banded females and southern green males and females were not.

In the quest to reduce insecticide applications, LSU AgCenter scientists next turned to site-specific insecticide applications. Because stink bugs are concentrated along field edges, spraying there could effectively control them and reduce both the amount of product used and the time required for application, reducing grower costs. One-half acre, small-plot field experiments were designed to test this hypothesis. Treatments included plots that never were sprayed (untreated check), plots that were completely sprayed (100 percent of acreage treated) and plots that had only the four rows on either side sprayed (25 percent of acreage treated). Insecticide was applied three times from pod filling to mature pods (Figure 2).

The results showed that perimeter insecticide applications compared with the untreated check delayed the redbanded stink bug plot colonization by two weeks. Treating only the perimeter also kept stink bugs below the action threshold when only one-quarter of the acreage was treated.

Clearly, understanding stink bug movement into fields and spraying only those areas where stink bug populations are highest can reduce insecticide applications and farmer costs. Further research will determine the effects of field applications of spinosad in combination with site-specific insecticide applications to field edges. If it works, this could reduce the number of insecticide applications for this pest even more, ensuring continued efficacy of products for stink bug control while reducing grower costs and negative environmental effects. ■

Double-cropping soybeans, wheat increases farm productivity

Kenneth W. Paxton, Donald J. Boquet and Robert E. Ferguson

The double-cropping of soybeans and wheat has become an increasingly attractive option economically for Louisiana farmers because of technological improvements, and about 85 percent of Louisiana wheat acres are double-cropped with soybeans. The LSU AgCenter has conducted a number of studies over the years examining this system.

Kenneth W. Paxton, Professor, Department of Agricultural Economics & Agribusiness, LSU AgCenter, Baton Rouge, La.; Donald J. Boquet, Professor, Macon Ridge Research Station, Winnsboro, La.; and Robert E. Ferguson, Assistant County Agent, Dean Lee Research Station, Alexandria, La.

From 2001 to 2009, a long-term analysis of the profit potential of a soybean/wheat double-crop was compared to a monocrop system. This study was conducted at the Macon Ridge Research Station in Winnsboro, La. At the start of the experiment, the field was prepared for planting the initial wheat crop. No other tillage was used during the experiment, except beds were periodically reshaped after fall harvest, if needed. The field was uniformly limed and fertilized each spring according to soil tests and recommended practices. The wheat crop was fertilized with nitrogen each year in mid-February. The summer soybeans were furrow-irrigated as needed to maintain adequate soil moisture for optimal crop development.

Wheat was planted in early to mid-November each year, and soybeans were planted immediately following wheat harvest, generally in mid-May. Monocrop soybeans were generally planted in late April or early May. Although the varieties planted changed over the life of the experiment, they were always recommended varieties for the area. Weed and insect control was based on systematic field scouting, and control measures followed recommended practices.

To assess profitability, enterprise budgets were developed for each system. For purposes of this analysis, costs were held constant at 2009 levels, and income was evaluated based on each year's crop yields and the annual average market prices for soybeans and wheat. While input prices have trended up over time, there was not as much variability in production costs as in returns. Yield differences and crop price volatility from year

Table 1. Estimated costs per acre, soybeans, no-till, multi-crop study, Winnsboro, La., 2009.

Item (Direct expenses)	Unit	Price $	Quantity	Amount $
Custom spray	Acre	21.50	1	21.50
Fungicides	Acre	11.82	1	11.82
Herbicides	Acre	42.87	1	42.87
Insecticides	Acre	12.40	1	12.40
Irrigation supplies	Acre	6.60	1	6.60
Seed/plants	Acre	33.00	1	33.00
Custom harvest/haul	Acre	10.70	1	10.70
La. hired labor	Hour	9.60	0.525	5.04
La. irrigation labor	Hour	9.60	0.156	1.50
La. operator labor	Hour	15.30	0.102	1.56
Diesel fuel	Gallon	2.50	10.330	25.84
Repair & maintenance	Acre	8.89	1	8.89
Interest on op. cap.	Acre	6.60	1	6.60
Total direct expenses				**188.32**

Table 2. Estimated costs per acre, soybeans/wheat double-crop, no-till, multi-crop study, Winnsboro, La., 2009.

Item (Direct expenses)	Unit	Price $	Quantity	Amount $
Custom spray	Acre	43.50	1	43.50
Fertilizers	Acre	111.60	1	111.60
Fungicides	Acre	51.53	1	51.53
Herbicides	Acre	39.05	1	39.05
Insecticides	Acre	19.00	1	19.00
Irrigation supplies	Acre	6.60	1	6.60
Seed/plants	Acre	57.30	1	57.30
Adjuvants	Acre	0.16	1	0.16
Custom harvest/haul	Acre	22.40	1	22.40
La. hired labor	Hour	9.60	0.844	8.09
La. irrigation labor	Hour	9.60	0.156	1.50
La. operator labor	Hour	15.30	0.17	2.60
Diesel fuel	Gallon	2.50	13.01	32.54
Repair & maintenance	Acre	12.94	1	12.94
Interest on op. Cap.	Acre	16.30	1	16.30
Total direct expenses				**425.11**

Figure 1. Soybean yields from monocrop (F/SB) and double-crop (WG/SB), production systems, Winnsboro, La., 2002-09.

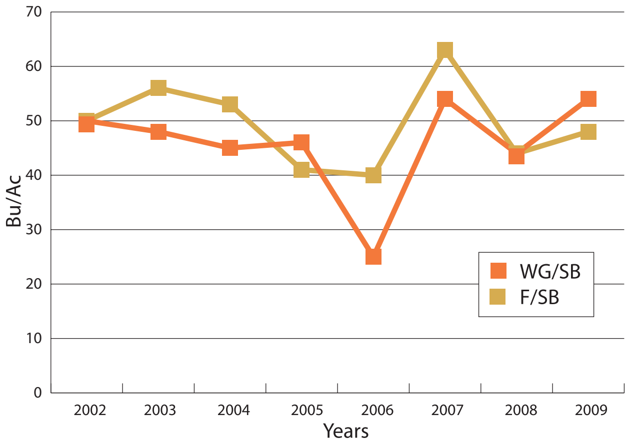
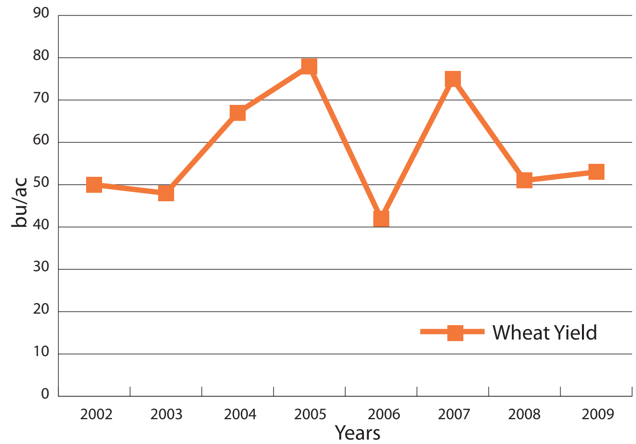


Figure 2. Wheat yield in double-crop production system, Winnsboro, La., 2002-09.



to year contribute to much more variability in returns than does variability in input costs for agricultural commodities. Further, because fixed costs differ little between the two production systems, only variable costs are considered here.

Soybean yields from the monocrop and double-crop systems are shown in Figure 1. The line depicting yields from the monocrop system (F/SB) is above the double-crop line (WG/SB). The difference in yield over the life of the experiment averaged about 3.6 bushels per acre. Although the double-crop soybeans had lower average yields, this system also had additional income from the wheat crop. As shown in Figure 2, wheat yields ranged from about 40 to almost 80 bushels per acre and averaged 58 bushels per acre from 2002 through 2009.

Figure 3 shows the returns above variable costs for the two systems over the life of the experiment. For most of the years, the double-crop system produced higher net returns than soybeans alone. Over the life of the experiment, the double-crop system net returns were $58.89 per acre higher than the monocrop soybeans. Based on this analysis, double cropping soybeans and wheat could add significantly to a producer's net income.

Although this analysis assumes commercial-size equipment to simulate a farm-scale analysis based on research-plot data, some important characteristics of commercial farming are not included. This analysis implicitly assumes adequate labor and equipment to accomplish all the required production practices. In actual farming situations, labor and equipment are not unlimited, and labor availability may impose limitations on the amount of a double-crop enterprise a farm may conduct. In addition, it is important to note that these research results were obtained using irrigation for soybeans. Irrigation is usually needed for consistent success with double-cropping, and restrictions in water availability could drastically alter the results. ■

Figure 3. Net returns per acre, soybeans and soybean/wheat double-crop, Winnsboro, La., 2002-2009.

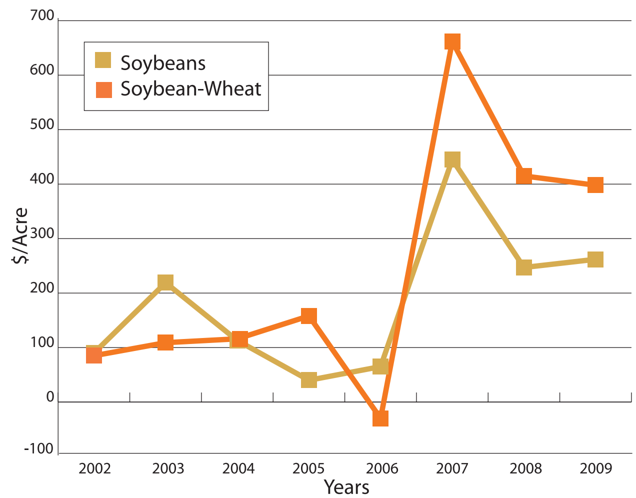


Photo by John Chaney

Soybeans are in the background, and wheat is in the foreground.

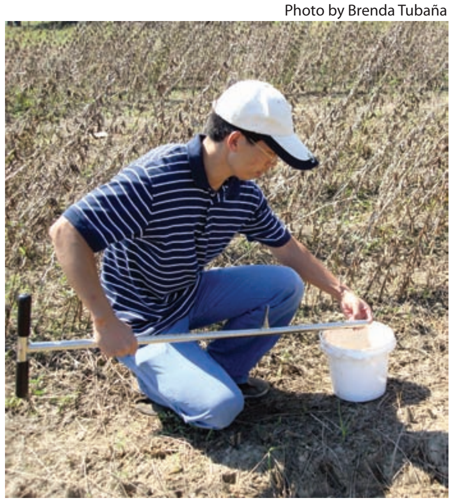
Soil Testing and Calibration Research in Soybeans

Brenda Tubaña, Jim Wang, J Cheston Stevens and Donald J. Boquet

For crops to grow, essential plant nutrients must be available in sufficient and correct proportions in the soil. Nutrients that crops need in the largest amounts, such as nitrogen, phosphorus and potassium, are the most limiting and often deficient in most crop production systems. Soil testing is a tool to obtain information about nutrient-supplying capacity of a soil and to provide a basis for deriving fertilizer rate recommendations.

Applying fertilizer in either insufficient or excessive amounts may result in reduced yields. An insufficient supply of essential nutrients directly inhibits normal growth and development of a crop and reduces yields. On the other hand, applying fertilizer in excessive amounts may cause a deficiency of another nutrient, too much vegetative production or increased incidences of pests or diseases, all of which result in reduced yields. In addition, applying too much fertilizer could reduce net income because of unnecessary costs not only of fertilizer but also weed and insect control.

Photo by Brenda Tubaña



Jianglong Yang, research associate at the School of Plant, Environmental, and Soil Sciences, collects soil samples from soybean plots at harvest.

Adopting effective soil test-based fertilization guidelines is among the best management practices producers can employ to ensure high yields. The existing soil-test-based fertilizer guidelines used by the LSU AgCenter Soil Testing and Plant Analysis Laboratory were established decades ago. Therefore, LSU AgCenter scientists are testing the validity of these fertilizer recommendation guidelines through correlation and calibration studies.

Correlation research establishes soil-critical levels below which a nutrient element is deemed deficient for optimum crop production, whereas calibration research optimizes the rate of fertilizer based on a specific source. For the past several years, LSU AgCenter scientists have focused on improving phosphorus fertilizer recommendations by revising the soil testing protocol.

Research trials were conducted at different sites in Louisiana from 2004-2010. Multiple soybean plots were established with different rates of phosphorus fertilizer. At harvest, yield results and soil samples were collected, processed and analyzed to determine the relationship among fertilizer rates, soil test values and yield. Results showed that for the new protocol, the critical soil test phosphorus level for soybean is 35 ppm (Figure 1). This represents the point beyond which

Brenda Tubaña, Assistant Professor, and Jim Wang, Associate Professor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La.; J Cheston Stevens, Associate Professor, Dean Lee Research Station, Alexandria, La.; Donald J. Boquet, Professor, Macon Ridge Research Station, Winnsboro, La.

Figure 1. Soybean yield response curve with soil test phosphorus (P) values established from correlation and calibration field trials conducted from 2004-2010 at different locations in Louisiana.

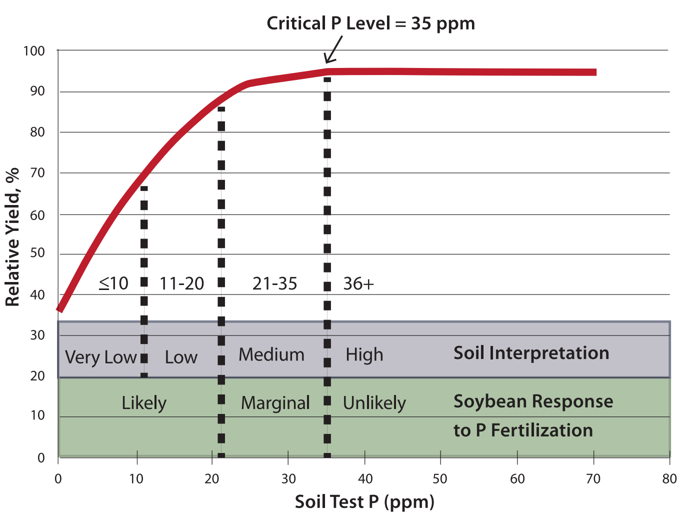
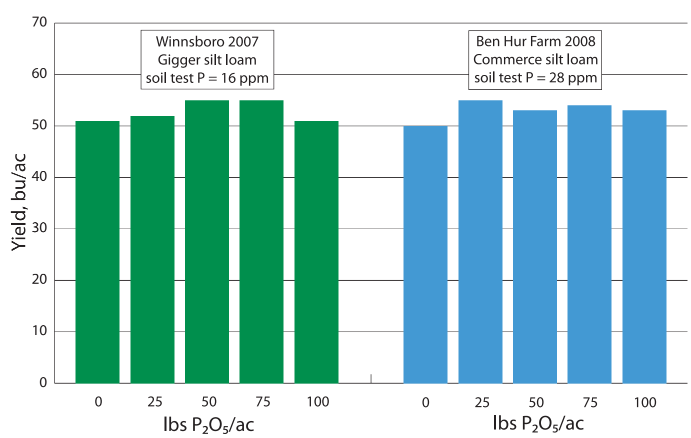


Figure 2. Yield response of soybeans to phosphorus fertilization grown on phosphorus-deficient soils at two locations in Louisiana.



there is no significant increase in soybean yield. In other words, when a soil is testing above 35 ppm, there is little or no chance of increasing yields from applying additional phosphorus fertilizer. On the other hand, applying phosphorus to soil testing less than 35 ppm phosphorus will likely increase yields. The soil testing lab uses a simplified soil rating of very low, low, medium and high based on soil test levels and on the probability soybeans will respond to phosphorus fertilization.

Phosphorus response studies conducted in Winnsboro in 2007 and at Ben Hur Farm in Baton Rouge in 2008 demonstrate the benefit of phosphorus fertilization to soybeans grown on soils that tested low and medium for phosphorus (Figure 2). A five-bushel-per-acre increase in yield was recorded with a 50-pound-per-acre application rate in Winnsboro when the soil tested "low." A similar increase was recorded for Ben Hur Farm when the soil tested "medium" with an application rate of 25 pounds per acre.

Several other locations showed no response to phosphorus fertilization even when the soils tested low to medium for phosphorus. This absence of response is attributed to other growth-limiting factors during the critical growth period. Further investigations of the complexities in soil nutrient dynamics may explain other differences in the properties of Louisiana soils. Findings from these correlation/calibration field studies also have provided information to update the recommended phosphorus application rates for soybeans at soil-test levels of very low, low, medium and high.

In Louisiana continuous soil testing and calibration research is necessary to regularly update fertilizer recommendation guidelines for phosphorus and other nutrients. This is necessary to keep pace with today's high-yielding crop production systems brought about by superior crop varieties, new production technologies and more effective production management practices. Moreover, it is important to develop diversified nutrient management plans to reflect the highly diverse nature of Louisiana soils. ■

Redbanded stink bug research continues

Progress is being made, but research continues on the redbanded stink bug problem in soybeans across the state of Louisiana.

LSU AgCenter entomologists Jeff Davis and Rogers Leonard are evaluating pest management strategies to reduce its potential damage to soybean. Experiments are being conducted in plots located from New Iberia to Bossier City and east to Winnsboro.

"We are continuing this study to determine the most effective economic threshold, biological control, and host plant resistance and chemical control strategies for the redbanded stink bug," Davis said.

This insect has a built-in tolerance to a number of the insecticides commonly used to control most stink bug species. Growers must spray more often to manage redbanded stink bug infestations.

"The problem with this intense spraying is if we keep using the same insecticides the pest will become resistant," Davis said.

Another problem caused by increased spraying is the destruction of beneficial insects that keep other pests from becoming established in the fields, Leonard said.

To avoid these problems, manipulation of planting dates and new varieties are being looked at as alternatives.

"We are looking at some of the new Pioneer varieties, which have shown lower infestations of redbanded stink bug compared to some other varieties," Davis said.

The redbanded stink bug is able to inflict an amazing amount of damage to the soybean crop because of the way it uses its piercing-sucking mouth parts, Davis said.

"This pest injects enzymes into the bean's seed, which dissolve it and then allow it to remove the liquid almost like a milkshake," Davis said. "They are able to pierce harder surfaces than you would expect."

Davis said this pest puts high stress on soybean plants causing them to stay green when the crop should be maturing, which decreases harvest efficiency.

"Sometimes the damage is so bad there is no reason to even harvest," Davis said. "There's just nothing there."

Not only do they cause yield loss just from feeding, but they also cause entry points for fungi into the seed pod as well, Davis said.

Under the most severe instances of seed injury, the damage is so bad the beans are turned down by the grain elevator. "When this happens about the only use is for hog feed," Davis said.

In 2011, the highest infestations of the pest are in the Jeanerette area. Davis said this may be because a number of cane growers are now planting soybeans on fallow sugarcane acres.

"Cane growers are taking advantage of the good price on soybeans right now by planting in late March and early April and harvesting in early August in time to put plant cane in," Davis said.

Stink bugs are a problem in the cane-growing areas of the state because of the warm-moist climate, and the soybean crop is planted there earlier than in many other areas of the state. In addition, host plants may be more available during the spring months and play a role in building populations.

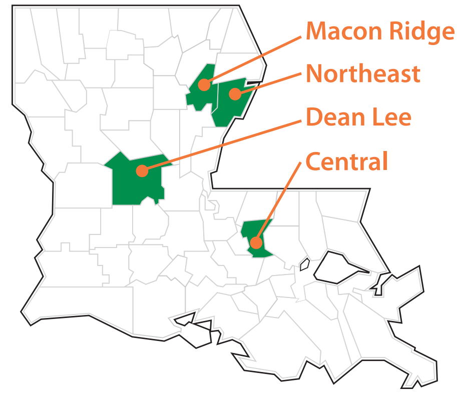
"Surprisingly, the numbers are low in the Delta so far this year," Davis said. It is believed that the cold weather along with the drought may be causing the suppressed numbers. However, this may be a false impression, and those numbers are likely to increase.

Davis said the end goal of the project is to have a website where growers can punch in the numbers found in their fields and be provided with a recommendation on when they need to spray. ■ **Johnny Morgan**

Soybean Green Plant Malady Contributing Factors and Mitigation

B. Rogers Leonard, Donald J. Boquet, Boyd Padgett, Jeffrey A. Davis, Raymond Schneider, James L. Griffin, Rodrigo A. Valverde and Ronald J. Levy Jr.

Figure 1. Louisiana research stations providing field trials to study the soybean green plant malady.



In recent years, soybean growers have experienced significant problems with mature plants retaining green leaves, green stems and green pods in soybean fields. The occurrence of these symptoms either alone or together has been termed the "green plant malady," which is also known as the "green bean" or "green plant" problem.

B. Rogers Leonard, Professor and J. Hamilton Regents Chair in Cotton Production; Donald J. Boquet, Professor and Jack and Henrietta Jones Professor; and Boyd Padgett, Professor, Macon Ridge Research Station, Winnsboro, La.; Jeffrey A. Davis, Assistant Professor, Department of Entomology, LSU AgCenter, Baton Rouge, La.; Raymond Schneider, Professor, Department of Plant Pathology and Crop Physiology, LSU AgCenter, Baton Rouge, La.; James L. Griffin, Professor and Lee Mason LSU Alumni Association Professor, School of Plant, Environmental and Soil Sciences, LSU AgCenter, Baton Rouge, La.; Rodrigo A. Valverde, Professor, Department of Plant Pathology and Crop Physiology, LSU AgCenter, Baton Rouge, La.; and Ronald J. Levy Jr., Professor, Dean Lee Research Station, Alexandria, La.

The green plant malady of soybeans is defined as an abnormal physiological condition when, after crop maturity should have occurred, main stems, leaves or pods remain immature. This problem can delay crop harvest and decrease the quality of harvested seed. In some cases this problem has prevented soybean harvest entirely. In other situations seed quality reductions can cause significant losses in value, or an entire load of soybeans can be rejected at the storage elevator because of excessive moisture or damaged seed.

Research scientists and soybean production specialists believed this condition could be induced by numerous biological agents or other factors, but no definitive research demonstrated these effects within current production systems. The only biological agent that had been associated with green plant malady symptoms was stink bugs, which caused severe pod and seed injury. During the past few years, however, the green plant malady has occurred in soybean fields where stink bugs have not been an issue. A few studies with fungicide efficacy have suggested that green leaf retention and green stems beyond normal crop maturity were related to the improved plant health caused by the fungicides.

Multidisciplinary research was initiated in 2008 and continued for three years to investigate factors that may contribute to this late-season green plant malady. Individual factors including insects (stink bugs), fungicide use, plant pathogens, variety genetics, herbicide applications and stress (moisture deficit) were evaluated for their effect on green leaf retention, green stems and green pods. Agronomists, weed scientists, plant pathologists and entomologists participated in a series of coordinated experiments to recreate the green plant malady in complex field experiments. The goal of the collaborating scientists was to gather information to better understand the issues associated with these problems

Photos by B. Rogers Leonard

Field view of 2009 Macon Ridge test site illustrating variation in symptoms of the green bean malady.

and determine if selected production strategies can mitigate the green plant malady and its effects on soybean yield and quality.

In field experiments at several Louisiana locations, the suspected causal agents were evaluated as single factors and in combination with other possible causes. These trials included several specific objectives. One was to survey entries in the commercial soybean variety trials for genetic differences in the incidence of green stems, leaves and pods at crop maturity. Another was to evaluate the effects of water deficiency, stink bugs, fungicide treatments and selected plant pathogens on the incidence of the green plant malady symptoms and seed yield. A third objective evaluated the use of herbicidal harvest aids to overcome the incidence of green leaves, green stems and green pods influencing normal crop maturity and harvest efficiency.

During the three years of research, a common observation was the association of weather-related plant stresses to this malady in which moisture deficits restricted plant growth, reduced insect pest infestations and limited the severity of plant diseases. The overall effect reduced the frequency of plants exhibiting green plant malady symptoms. Other observations were as follows:

- Selected entries in the LSU AgCenter soybean variety trials exhibited large differences in green stems ranging from zero to 100 percent. Varieties exhibiting 100 percent green stems were common, and there appears to be a genetic predisposition to this specific symptom of the green plant malady. Incidences of green leaf and green pod retention were not as consistent or common. Funding from the Louisiana Soybean and Feed Grains Research and Promotion Board suggested these results to be included in the LSU AgCenter soybean variety recommendations.
- Results from several trials associated moderate drought stress with green plant malady symptoms. Extreme drought stress, however, caused plants to die prematurely and was inconsistent in producing the same symptoms. These results varied by location and soybean variety.
- Selected strobilurin fungicides, such as Headline, increased green leaf retention, green stems and green pods at harvest compared with plants in nontreated plots. This result should be expected because fungicides promote healthy plants, and nontreated plants may have been infected with plant pathogens that caused premature leaf aging or crop maturity. However, applications of this fungicide to some varieties resulted in green stems even though pods had matured and leaf aging was complete. This was unexpected and is not normal. There is a genetic component to this relationship because not all varieties responded in the same manner.
- Soybean plants exhibiting green stems were collected from various locations and analyzed for the presence of viruses, including the soybean mosaic virus, bean pod mottle virus and cucumber mosaic virus, which are associated with this problem in other states. AgCenter scientists, however, found no relationship between these viruses and the green plant malady.
- Stink bugs have been the most yield-limiting insect pest in Louisiana soybeans during the past few years, and infestations were associated with severe instances of the green plant malady. Moderate populations near the treatment action threshold that persist for an extended period or reach outbreak levels two to three times the action threshold can severely damage seeds and result in green

Photos by B. Rogers Leonard

Varietal expression of green stems and green leaves. The variety on the right is exhibiting both green stems and excessive green leaf retention in spite of mature, brown pods.

Normal crop maturity (left) and stink bug-induced symptoms of the soybean green plant malady (right).

Photos by B. Rogers Leonard

Soybeans treated with a fungicide displaying green stems.

Nontreated soybeans with the appearance of normal maturity but with a heavy incidence of pod diseases and poor seed quality.

leaves, green stems and green pods in defined field areas or across entire fields.

- Leaf retention, the incidence of green stems and increased seed moisture in field plots associated with the green plant malady were reduced when the herbicide paraquat was applied as a harvest aid.

This research has provided essential information that can be used to better understand the issues associated with the soybean green plant malady. Farmers who want to minimize the symptoms of this soybean disorder can select varieties that do not express green stems at harvest. However, there is some evidence that high yields correlate with green stems, and this needs further evaluation. Several of the highest-yielding soybean varieties displayed 70-100 percent green stems.

Green stems can be considered a normal genetic characteristic of some varieties. Excessive green leaf retention or green pods after maturity are an abnormal response of a variety and indicative of the soybean green plant malady. Dates of expected crop maturity are included in the soybean variety trial information and should be used to determine if the presence of these symptoms indicates abnormal crop maturity.

Producers should use all available production practices to reduce the effects of environmental stresses on soybeans. Fungicides may be necessary to reduce the yield–limiting effects of pathogens, but these treatments can increase the incidence of the green plant malady. Current stink bug treatment action thresholds and chemical control strategies are sufficient to manage insect pests and reduce the incidence of excessive green stems, green pods and delayed crop maturity. However, multiple treatments may be required to manage persistent and high infestations of insect pests.

Delayed crop maturity can cause poor harvest efficiency. Immature pods, green stems and green leaves allow more foreign matter to be collected during harvest, which increases harvest difficulty. A chemical harvest aid such as paraquat can be an important production tool in some situations to overcome the negative consequence of the green plant malady. Application timing of harvest aid is critical to managing harvest efficiency. ■

Soybean green plant malady effects on seed quality.

Effectiveness of a chemical harvest aid, paraquat, in desiccating soybean green leaves (right) compared to nontreated plants (left).

Therapeutic Proteins from Soy

Jack Losso

Epidemiological observations have consistently shown that incidences and mortality rates of cancers, diabetes, multiple sclerosis, Alzheimer's disease and several chronic degenerative diseases vary significantly across regions of the world. Populations whose major diets are mainly centered on plant foods tend to have lower rates of these diseases. In the western world, however, the rates of colon, breast and prostate cancers, multiple sclerosis, diabetes and Alzheimer's disease are high.

The rates of cancer among populations migrating from low- to high-incidence countries can change markedly. In most cases, they approximate the rates in the new region within one to three generations. This indicates that the primary determinants of cancer or other chronic diseases are not genetic but rather environmental and lifestyle factors that could, in principle, be modified to reduce chronic diseases in high-risk individuals. While in most cases genetic determinants appear to affect 5-10 percent of the population, in the last two decades a primary factor of interest, apart from tobacco, has been diet.

Proteases are enzymes that help the body change proteins into substances it needs. They facilitate many normal physiological functions as well as changes that accompany disease or injury. These include digestion, healing, disease defense, blood coagulation and the activation of proteins that are precursors to enzymes and hormones. An imbalance that favors proteases over their inherent inhibitors in the body may trigger the uncontrolled breakdown of proteins, which leads to irreversible tissue destruction, such as inflammation, rheumatoid arthritis, periodontitis, hypertension, gastric ulcers, muscular dystrophy, tumor growth and the spread of cancers.

Proteinase inhibitors, which frequently are involved in chronic diseases, are compounds that deactivate protease and stop their uncontrolled activities. Identifying natural products that can inhibit protease activities is what pharmaceutical industries and food scientists are always searching for.

Soybean seed is a rich source of protein and contains an average of 34.9 percent proteins. Soybean proteins are the "functional parts of soy products, such as soy milk, tofu and soy vegetables. Soybeans also are a rich source of bioactive proteins including the Bowman-Birk inhibitor (BBI) and Kunitz trypsin inhibitor. Both proteins have been extensively investigated for their efficacy against proteinases involved in human diseases.

The uniqueness of soybeans among other legume seeds lies in the ability to contain inhibitors for almost every class of proteinases involved in human diseases. The BBI is a 71-amino acid, water-soluble protein found in most soy products. It is very stable and bioavailable. Several studies have shown its health-enhancing benefits. In cell cultures, BBI is known to inhibit enzymes associated with cancer cell invasion and proliferation. Astronauts on space missions are likely to experience deficiency in blood antioxidants and exposures to space radiation, which significantly increase the incidence rate of malignant lymphoma and rare tumor types, malignant lesions of bone marrow, tumors originating in blood cells and cataracts. In animal models of space exposure, BBI has been shown to counteract these effects.

Tumor cells are often bent and twisted and disconnected from each other, making it difficult for drugs to penetrate and kill all the cells. This disorganized structure has been associated with the reduction or loss of proteins called connexins, which allow adjacent cells to connect. BBI has been shown to counter the loss of connexins in disease cells. The efficacy of BBI in the treatment of ulcerative colitis has been demonstrated in animal models of the disease, and BBI has shown beneficial effects in patients with ulcerative colitis with no side effects. BBI in the form of a concentrate known as BBIC has been used in Phase I, II and III trials as a human cancer-preventive dietary supplement.

Multiple sclerosis is an autoimmune disease whereby inflammation generates proteases that destroy the myelin sheath that insulates nerve cells. Multiple sclerosis is associated with muscle weakness, difficulty with coordination and balance, partial or complete paralysis, and cognitive impairment. Although there is no real cure for multiple sclerosis, available treatments often require frequent injections of anti-inflammatory drugs that have significant side effects. Research has shown that BBI, which penetrates the central nervous system, delays the onset and suppresses the severity of multiple sclerosis in rats and may have application in human therapies.

While BBI is present in soy products, no specific methods are available to measure the levels of BBI in soy products, including soy milk, soy burgers, soy vegetables and tofu. LSU AgCenter researchers have developed an antibody against BBI that will be useful in determining the levels of BBI in soy products. ■

Jack Losso, Professor, Department of Food Science, LSU AgCenter, Baton Rouge, La.

Photo by John Wozniak

Advances in molecular biology lead to soybean disease control

Svetlana Oard and Zhi-Yuan Chen

Every crop can be damaged by many different diseases and pests throughout its life cycle. In common practice, growers apply pesticides to control different pathogens and insect pests and protect a crop from all possible diseases and pests. This entails enormous economic and environmental costs. Developing broad disease resistance in plants instead of developing resistance for individual pathogens can save time and resources. This is why for the past several years LSU AgCenter researchers have been using biotechnology to find ways to control various crop diseases, such as Asian soybean rust and cercospora leaf blight. Both diseases, especially the former, have the potential to cause severe soybean yield losses in the southern United States.

Thionins are basic plant peptides with broad-spectrum, anti-microbial activity. Enhancing thionin production and accumulation in plants has potential to promote broad disease resistance against bacterial and fungal pathogens. Thionins are excellent candidates for developing a broad-range plant defense system. They exhibit broad activity against bacteria and fungi at low concentrations and have the ability to rapidly damage microbial cells. Seed thionins are abundant in wheat and barley flour and are safe for human consumption. Introducing antimicrobial peptides through plant transformation could offer a solution for creating crops with targeted resistance to a wide range of bacterial and fungal pathogens.

Developing antimicrobial and especially antifungal resistance is a challenging task that requires effective levels of thionin production and a delivery system to ensure thionin accumulation where pathogens enter a plant. LSU AgCenter researchers have addressed several challenges in developing a strategy for transgenic expression of thionins. These include producing edible, seed-derived thionins in leaf tissues; expressing a highly effective peptide without damaging plant cells; and reaching levels of activity in plant leaf tissues sufficient for inhibiting bacterial as well as fungal pathogens.

The result of this work was a hybrid signal peptide and an improved thionin gene that provides antimicrobial resistance in leaf tissue. Successful production of biologically active, seed-derived thionin in leaf tissues requires a specific signal peptide that has three main functions: to protect plant cells from the harmful activity of thionin, to excrete thionin outside the plant cell, and to deliver it to the plant cell wall where thionin awaits for pathogenic microbes. The hybrid signal peptide does it all, providing antimicrobial resistance in plant leaf tissue. Up to 60 percent increase in antifungal resistance was demonstrated in a true-breeding line of a model plant – Arabidopsis – that was charged with the fungus *Fusarium oxysporum*.

The Asian soybean rust pathogen is capable of devastating soybean fields. Currently, no commercial soybean varieties in the United States have genetic resistance to this pathogen. Introducing the new thionin gene could protect soybeans from Asian soybean rust as well as from other fungal and bacterial pathogens. A successful transformation vector to introduce the seed-derived thionin into soybeans demonstrated high levels of transgene production. The next step is to use the vector for a formal soybean transformation experiment to select a line with high levels of production and test it for antimicrobial activity. The created gene has been given to the U.S. Department of Agriculture for additional testing in tobacco and cotton to demonstrate broad-range resistance.

In addition to transgenic approaches, researchers have been using proteomics, a state-of-the-art technique to study the full set of proteins in a plant to find soybean proteins either highly present in disease-resistant soybean varieties or are induced upon pathogen invasion. Some of these differentially produced proteins are believed to play important roles in enhancing host resistance to various pathogens. This approach is more cost-

Zhi-Yuan Chen, right, and his student Sunjung Park evaluate different soybean lines for levels of resistance to Asian soybean rust.

Svetlana Oard, Associate Professor, School of Plant, Environmental & Soil Sciences, LSU AgCenter, Baton Rouge, La., and Zhi-Yuan Chen, Associate Professor, Department of Plant Pathology & Crop Physiology, LSU AgCenter, Baton Rouge, La.

effective and less time-consuming than the traditional plant-breeding approach in identifying candidate genes to enhance host resistance.

Several such proteins have been identified in soybeans infected by rust. The importance of these proteins in host resistance to Asian soybean rust, however, needs to be first verified.

The normal approach is to either over-produce the target protein or silence it through genetic engineering and soybean transformation, which can take two to three years. Instead, researchers are taking a novel approach called virus-induced gene silencing to reduce the production of these proteins one at a time so their importance in host disease resistance can be determined in a matter of several months. Through collaboration with scientists at Iowa State University, several candidate genes have been inserted into a mild version of bean pod mottle virus. These modified, nonpathogenic viruses will be introduced into soybean plants in a controlled growth chamber in the laboratory to see whether reducing the production of candidate proteins can cause a significant increase in susceptibility to fungal pathogens. If the answer is yes, it indicates this particular protein plays a critical role in soybean resistance to the fungal infection. Then, the production of this candidate protein can be increased through breeding or genetic engineering to enhance soybean resistance to these pathogens.

Researchers also are applying biotechnology to combat cercospora leaf blight disease. They have developed specific DNA probes that can reliably detect the presence of the cercospora pathogen in field-grown soybean plants one to two months before the disease symptoms appear. This procedure is called real-time polymerase chain reaction, and it can detect the presence of target pathogen DNA with extreme sensitivity. This early detection method has allowed LSU AgCenter plant pathologists to develop a more effective fungicide regimen to control leaf blight disease by following the increase of fungal DNA after the treatments.

In addition, researchers are exploring ways to make fungal pathogens less aggressive on soybeans, such as by reducing cercosporin toxin production through targeted gene disruption or reducing pathogen growth through "transgene silencing," a phenomenon that has only been discovered in a few plant systems.

Although all these studies are still in their early trial stages, the knowledge generated from these studies can provide soybean growers with more effective and environmentally friendly strategies to control diseases in soybeans and other crops. ■

Extracts from soybeans find beneficial uses

Cristina Sabliov, working with a team of scientists in the LSU AgCenter's Department of Biological and Agricultural Engineering, has developed a continuous microwave system that can be used to extract beneficial compounds, such as isoflavone oils, from soy flour.

The process is faster and more cost-effective, energy-efficient and environmentally friendly than traditional extraction methods. The resulting isoflavone oil has antioxidant properties and could be used in vitamin supplements or put into functional foods.

Sabliov has been working on this process for several years, starting with small-scale microwaves. The team, which includes Dorin Bolder and Marybeth Lima, is working on a large-scale microwave extraction system that could be used in a commercial setting.

The team's research objectives include optimizing a scaled-up system while demonstrating its viability for commercialization. The researchers plan to make the extraction process even more cost-effective through recycling and waste byproduct recovery. Sabliov said the used soybean flour, left over after oil extraction, can be analyzed for potential use as an animal feed.

Sabliov's work is relevant to food scientists who can use the extracted isoflavones in their research. Zhimin Xu in the LSU AgCenter's Department of Food Science is using the extracted soy isoflavones as a preservative in ground meat. When ground meat and sausages are manufactured, synthetic preservatives are added.

"We want to replace those with this natural soy extract," Xu said.

The extract is a natural antioxidant that works by preventing lipid oxidation, which leads to meat spoilage. Xu's work has shown the soy extract can effectively prolong the storage time of ground meat.

Xu's recent work focused on increasing the antioxidant level of the isoflavones. This would allow him to add less extract to the ground meat while maintaining its preservatives and the meat's flavor, texture and color.

Another function of a preservative is to act as an antimicrobial, preventing bacteria from spreading. Xu also studies microbial growth in ground meat to determine if this natural preservative will help inhibit it.

Among other research in the food science department is Jack Losso's work with extracting lutein, a beneficial antioxidant, from distillers grains, a byproduct of the ethanol process. Losso obtained a patent for his process that isolates the lutein from corn, even aflatoxin-contaminated corn. Lutein is useful in delaying or preventing vision loss through macular degeneration.

"Lutein has good properties of keeping cells together, and cell communication is important when a disease occurs," Losso said.

Losso said that diseased cells in chronic degenerative diseases such as macular degeneration or cancer do not communicate with each other. This makes it difficult for drugs to move around diseased cells and act properly, but lutein can help restore communication. Losso is working on developing a lutein delivery system so the compound could be added to foods or medicines.

He also plans to look into lutein's ability to prevent low-grade inflammation associated with Alzheimer's disease. ■ **Tobie Blanchard**

Louisiana Soybean Research Verification Program

Ronald J. Levy Jr.

The Louisiana Soybean Research Verification Program allows producers a chance to participate in a program that demonstrates profitability through improved agronomic and cultural practices.

In Louisiana, according to the National Agricultural Statistics Service, soybean producers averaged 41 bushels per acre on 1,020,000 acres in 2010. The U.S. average was 43.5 bushels per acre for 2010. Recently, higher soybean value and increased yields because of improved genetics and management have resulted in soybean profitability becoming the norm, barring natural disasters.

The trend has been increased yields. Some producers consistently produce high yields and make a profit farming soybeans using the technology and information sources available to all Louisiana producers. Many soybean producers, however, are not taking advantage of the data generated by the LSU AgCenter. In addition, some do not manage their soybean crops as primary production income sources. For example, rice farmers will rotate fields into soybeans to preserve the quality of the soil.

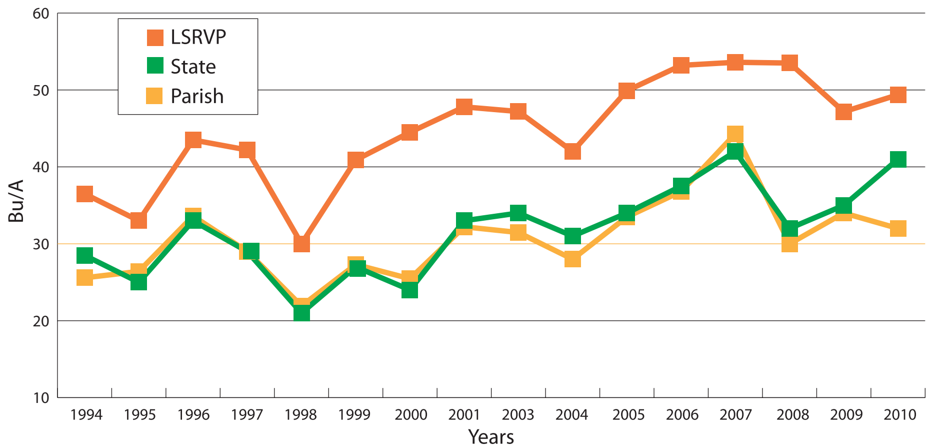
This Louisiana Soybean Research Verification Program was designed to combine production and management recommendations and persuade soybean growers that LSU AgCenter recommendations are sound and can improve profitability.

The objectives of the program are to:

- Conduct on-farm field trials to verify the research-based recommendations from the LSU AgCenter with the goal of maximizing profitability.
- Increase the confidence of producers, county agents and specialists in LSU AgCenter recommendations.
- Continue to build a good cost data base for soybean production in Louisiana.
- Provide data on various production systems as to yields and cost.
- Demonstrate what the higher-yielding fields have in common in addition to refining existing recommendations.
- Aid researchers in identifying areas of soybean production that may need additional research.

The verification program was implemented in 1994 to demonstrate to soybean producers that current research is available to help improve profit. Producers are selected from representative soybean-producing areas in the state that use different cropping systems. The county agent in the parish chooses the participating producer. The only stipulations are that the producer must make every effort to follow AgCenter advice as closely as is practical. Each county agent will have backup support from the project coordinator and from a team of state specialists in the various phases of production and management.

During the winter, a management plan including an individual objective for each field in the program is developed for the producer. The project coordinator makes the selection of the field with input from the producer, agent and other specialists. Selection depends upon whether there is potential for improvement in yields and profits. The grower's best or poorest field is not selected, but



The Louisiana Soybean Research Verification Program (LSRVP) has had a positive effect on yields. The orange line shows the average yield of those fields in the program. The green line shows the state average, and the gold line shows the average of the parishes in which there is a field in the program.

Photo by Bruce Schultz

Garrett Marsh of Tallulah, left, is one of the farmers participating in the Louisiana Soybean Research Verification Program. Ron Levy directs this program.

Ronald J. Levy Jr., Extension Soybean Specialist and Interim Director of the Central Region, LSU AgCenter, Alexandria, La.

rather an average one with potential for improvement. In each field, a soil test analysis will be conducted for plant nutrients and for possible damaging nematodes. Consultation between the grower and AgCenter personnel will begin as soon as the fields are selected. During the growing season, the agent will monitor each program field at least once a week with one of the state specialists. As the expertise of others is needed, they will be included. Input during the season will be provided by specialists in weed science, entomology, farm management, plant pathology and soil fertility. During each farm visit, observations will be recorded, and any inputs or recommendations to be made to the grower will be noted.

The verification program will be conducted for a maximum of two years with the same grower and, preferably, not on the same field each year.

Verification fields were established in the parishes of Madison, East Carroll, West Carroll, Catahoula, Richland and Vermilion, and two were in Concordia Parish in 2010. There are 10 verification fields across the state planned for 2011.

The biggest thing producers say they have learned is how critical timing is for all applications of herbicides, insecticides, fungicides and harvest aids to get the most economic benefits.

The Louisiana Soybean Research Verification Program shows that research is applicable to soybean production fields and can help producers improve profitability and sustainability. ■

Soy protein, rice bran oil added to mayonnaise-like product

Sensory tests of a mayonnaise-like product made from soy protein and rice bran oil got high marks from a consumer study in which people were asked to taste and evaluate the product developed by LSU AgCenter researchers.

The project began with recognition that a third of U.S. adults have some form of cardiovascular disease, said Witoon Prinyawiwatkul, an LSU AgCenter food scientist.

"Heart disease and stroke are leading causes of death," Prinyawiwatkul said. "Soy protein and rice bran oil can contribute to a diet low in saturated fat."

The sensory testing was conducted by Karen Garcia, a graduate student who worked with Prinyawiwatkul while completing her master's degree.

Garcia's study began with 10 formulations of a spread made with rice bran oil and soy protein. The oil content ranged from 30 percent to nearly 60 percent, and the soy protein ranged from one percent to 11 percent. The study was conducted with 360 consumers on the LSU campus in Baton Rouge.

Tasters were asked if they liked the product, its appearance, its color, its mouth feel, its flavor and other sensory characteristics, Garcia said.

Commercial mayonnaise is made of soybean oil, egg yolks, vinegar and spices. The researchers' product is made with rice bran oil, which has a cholesterol-lowering effect, and soy protein, which replaced the egg yolk. Without eggs, the unflavored product is cholesterol-free.

"Mayonnaise is one of the most popular U.S. condiments," Garcia said. But, she pointed out, the tested product can't be called a true mayonnaise.

"To be called mayonnaise, a product has to contain at least 65 percent oil," Garcia said. "Most commercial mayonnaise is 70-80 percent oil."

The soy protein and rice bran oil product has far less oil, which means fewer calories.

Garcia said studies report rice bran oil can contribute to lower LDL, which is termed the bad cholesterol and a contributor to cardiovascular disease.

"We tried to come up with a partial solution to contribute to a diet low in saturated fat," Prinyawiwatkul said. "Rice bran oil has a cholesterol-lowering component, but we need to point out that soybean oil is not bad. Both rice bran oil and soybean oil have more than 80 percent unsaturated fats."

Rice bran oil contains gamma oryzanol – a functional food – which has been said to serve as an antioxidant and to contribute to lowering cholesterol, Prinyawiwatkul said. The oil also contains other plant sterols and the antioxidant tocotrienol.

In the taste test, 360 adult consumers were asked their impressions of the spreads. Then they were then asked, "Would you buy this product?" After they answered, the tasters were told about its potential health benefits and asked again if they would buy it, Garcia said. When they heard about the health benefits, that number increased by 13 percentage points.

In a follow-up study, 100 tasters were presented with the most popular formulation from the first test but with a twist. The product was offered with three flavorings – sour cream and onion, cheddar cheese and sour cream, and Monterey jack cheese. The preferred formulation included 37 percent rice bran oil and six percent soy protein.

With the addition of the flavorings, tasters' willingness to purchase the product jumped to 65 percent, Garcia said. And after hearing about the health benefits, the number rose to 77 percent. On top of that, 97 percent responded "yes" when asked if they deemed the product "acceptable."

The product has a wide range of uses, the researchers said. Although it cannot be called mayonnaise, they call it a mayonnaise-type spread. With flavorings, it could be used as a condiment; the basis for a tuna, chicken, ham or other sandwich filling; a spread for crackers and as an added ingredient in any number of food recipes.

The spread can be an alternative healthy food, the researchers said. But because it contains a vegetable oil, it still has high calories.

"Soy protein provides functionality and, of course, health benefits," Prinyawiwatkul said. ■ **Rick Bogren**

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LSU AgCenter
P.O. Box 25100
Baton Rouge, LA 70894-5100

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Photo by Bruce Schultz

Ron Levy, extension soybean specialist and interim director of the LSU AgCenter Central Region, uses a sweep net in a soybean field to see if he can capture any insects. In this scouting procedure, a certain number of sweeps are conducted and then the insects captured are identified and counted. These counts are then compared to threshold levels established for the crop and the insect. If the number reaches a predetermined level, then the field is sprayed with insecticide as a control measure.