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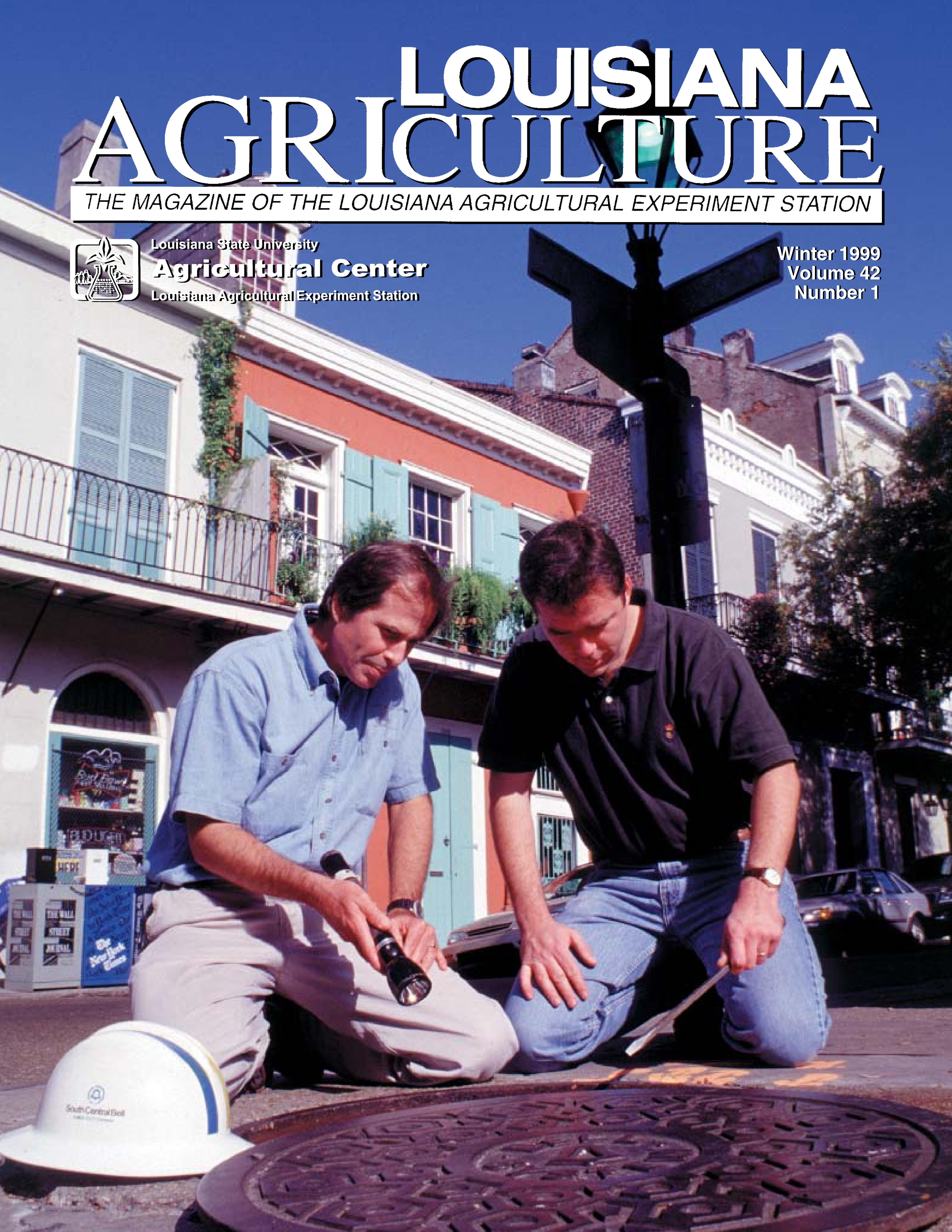

Reproductive physiology program helps save endangered species, too

Survival for many endangered wildlife got a boost recently when representatives from the Louisiana State University system and the Audubon Institute in New Orleans signed an agreement to work more closely together on animal reproduction projects.

One of their first projects will be trying to save endangered tigers by using lions as surrogate mothers.

"We are testing ways to use more common animals as surrogate mothers for animals that are more rare," said Robert Godke, director of the reproductive physiology research program at the LSU Agricultural Center, one of the cooperating entities. His program has gained a worldwide reputation for pioneering work in the development of assisted reproductive techniques in farm animals.

He is working with Earle Pope, a scientist at the Audubon Center for Research on Endangered Species (ACRES). Since last May in more than a dozen attempts, they have taken eggs from female tigers at the Baton Rouge Zoo, combined them with sperm from male tigers at the Audubon Institute and transferred the embryos into female lions at the Audubon Institute. So far no pregnancy, though.

"These things take time," said Richard Denniston, LSU Ag Center research associate. "This has never been done before. But we know there is the potential for inter-species transfer."

Signing a formal agreement allows sharing of equipment and personnel. It also becomes easier to procure funding that can benefit both institutions.

Another project involves saving bongo antelopes in Africa from extinction by using the more plentiful eland antelopes as surrogate mothers. Scientists at LSU's School of Veterinary Medicine have traveled to Kenya with bongo embryos which they then transferred to eland females. If any of the resulting pregnancies is successful, the world will see new bongo babies in early 1999. ■ **Linda Foster Benedict**

Photo by Mark Claesgens

Louisiana has become a worldwide leader in research on saving endangered species. One reason is the cooperation between the Louisiana State University system and the Audubon Institute in New Orleans. To formalize this partnership, officials from the two institutions signed an agreement. From left: Greg O'Brien, chancellor of the University of New Orleans; Bill Jenkins, LSU chancellor and newly named president of the LSU system; Bill Richardson, LSU Ag Center chancellor; Ron Forman, Audubon Institute president and CEO; Steve Perry, chief of staff for Gov. Mike Foster; and Ron Miller, a vice president with Freeport-McMoRan, a corporate sponsor. The two cats are an endangered species called cervals. One of their trainers is Jeff Vaccaro, at right, with the Audubon Institute.

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ARTICLES


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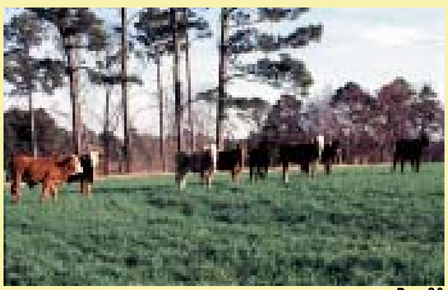
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COVER
LSU Agricultural Center scientists Gregg Hendeson, left, and Chris Dunaway are involved with a project to save the French Quarter in New Orleans from damage from Formosan subterranean termites. See page 4. (Cover photo by John Wozniak)


LE MENU
Cabildo en papillote
Cathedral soufflé
Pontalba crêpes

Keeping Formosan termites away from underground telephone lines

Gregg Henderson and Chris Dunaway

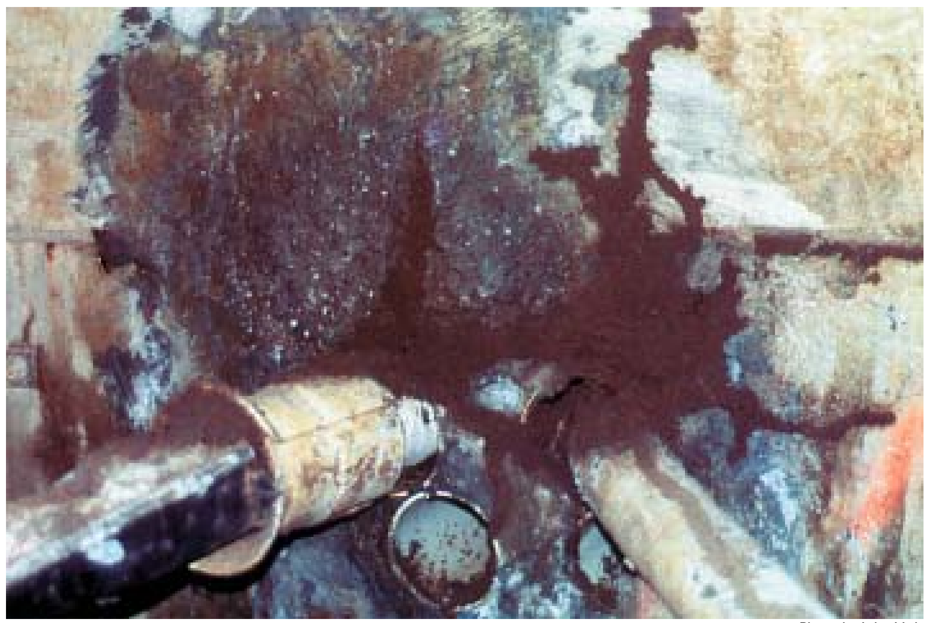
The Formosan subterranean termite is a formidable adversary. Foraging aggressively and quickly reducing wooden structures to paper-thin sheaths, this species of termite has been a particular menace in the New Orleans area for more than 30 years. There seems to be no end to the list of materials the Formosan termite will eat in its pursuit of cellulose, the major constituent in wood. Evidence of this was the discovery that Formosan termites were damaging buried telephone communications equipment by eating through the polyvinyl chloride (PVC) casing. Although the termites cannot directly harm the copper wire, by breaking the watertight seal, they allow in moisture. This can cause corrosion or short circuits, possibly leading to loss of service. BellSouth has estimated that the cost required for repair caused by the Formosan termite in New Orleans had reached $400,000 in 1993.

Similarly, power outages have occurred in underground electrical lines owned and operated by the local electric company. For example, a major power outage in 1993 affected several hospitals and, in 1998, shut down the French Quarter. Formosan termites were thought to be the probable culprit.

This is the bait that is placed underground to keep the termites from eating the cables.

Illustration by Elma Sue McCallum

The LSU Agricultural Center has been involved with a cooperative study funded by BellSouth Telecommunications and FMC Corp. for the past five years. The goal of the study has been to develop an effective control system for the telecommunications environment. Liquid termiticides are ineffective for this purpose and could potentially endanger BellSouth employees and contaminate local bayous and lakes. Regular tracking powders (toxicants in a dust formulation) would quickly become wet and wash away. A bait system that contains a slow-acting toxicant in a child-resistant container would be ideal for the cable system. Baits can affect a larger population of the targeted pest than only those feeding directly, since food is transferred back to nest mates. In addition, when the need arises, the baits can simply be removed from the site, thus drastically reducing any potential off-target contamination.



Some of the underground damage done by the Formosan termites. Photo by John Holt

Starting in 1993, tubular baits about 3 inches long and 1.5 inches in diameter and containing up to 100 parts per million of sulfluramid on a cardboard matrix were placed in manholes having Formosan termites. These baits include a slow-acting stomach poison developed by the U.S. Department of Agriculture in the late 1980s in a bait formulation for use against fire ants. Baits were placed close to termite activity to increase the likelihood of the termites finding and feeding on them. Between 1993 and 1995, 14 manholes were baited, and all but one site showed complete cessation or reduced termite activity.

Although the treated cardboard was effective against the termites, it quickly degraded in the wet conditions of the junction chambers. Furthermore, the raw

Gregg Henderson, Associate Professor, and Chris Dunaway, Research Associate, Department of Entomology, LSU Agricultural Center, Baton Rouge, La.

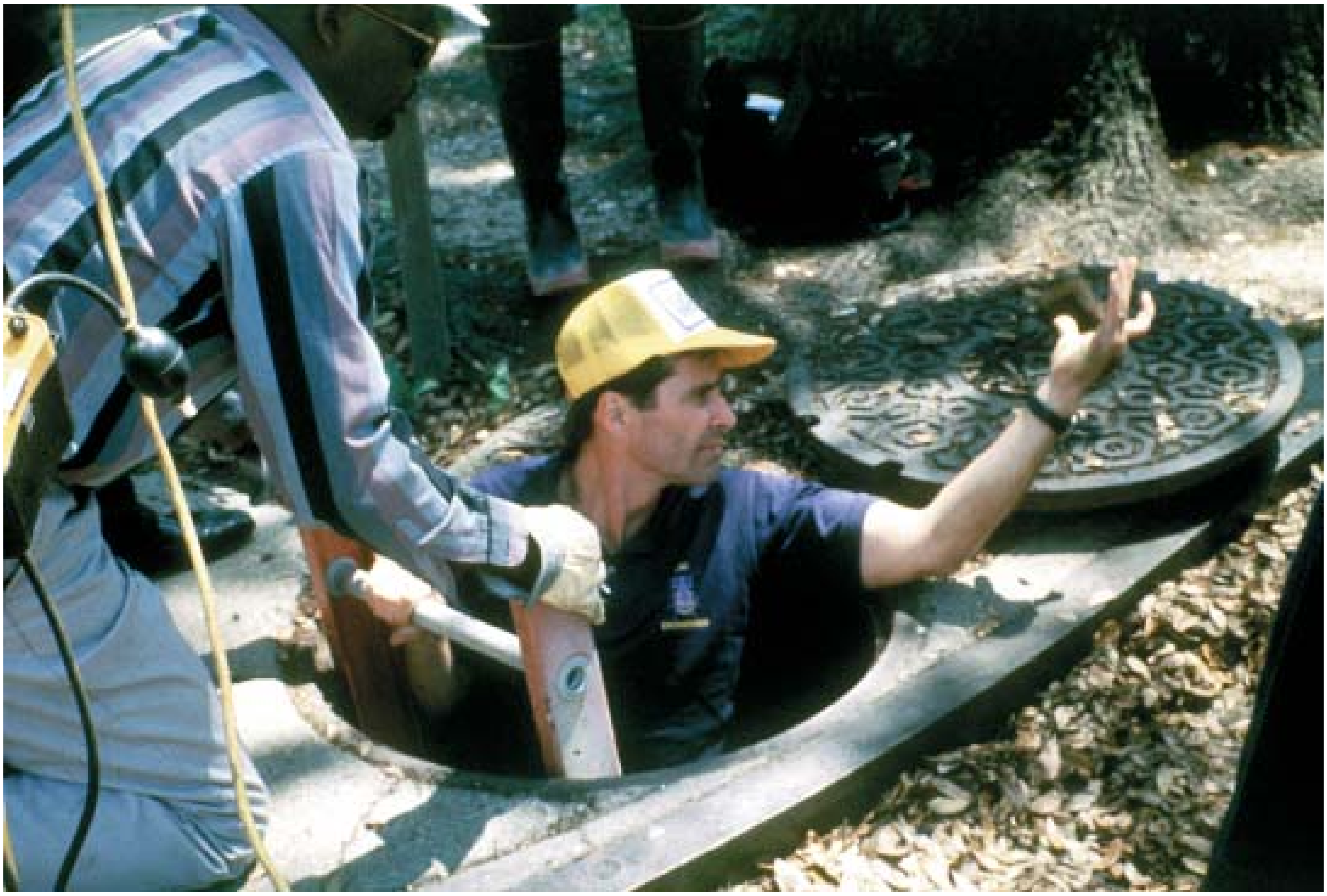


Photo by Jon Felix

Gregg Henderson going down into a manhole in the French Quarter to place termite baits.

bait material used in the early studies did not meet federal registration requirements for minimal human contact. After trying several techniques, it was determined that a wax coating could be applied to the baits, making them watertight without inhibiting termite acceptance.

The coated waterproof baits were then placed in plastic containers with small holes in the sides. The containers provided protection from other pests, inhibited unintentional human contact with the bait and could be installed in a variety of ways according to the situation.

In 1996, the new bait systems were tested at 15 sites. Observations made through February 1998 revealed that eight of the sites were termite-free. At the other sites, numbers of foraging termites were reduced. In some cases, the numbers dropped from several hundred to fewer than 20.

The manholes are an ideal place for the termite baits since food choices are limited around the underground cables. The baits also help reduce the number of termites that could pose a danger to wood in the general vicinity of where baits are placed. ■

Formosan subterranean termite facts:

- The Formosan subterranean termite is one of three important subterranean species in Louisiana. The other two are the southern subterranean and the eastern subterranean. The Formosan is the most ferocious of the three.
- The Formosan termite is what biologists call a social insect. Along with species of bees, wasps and ants, termites form societies in which individuals divide up tasks such as foraging and reproduction. This elaborate system of relationships and interactions gives termites the ability to act collectively.
- Formosan termite colonies can include as many as 10 million members.
- Nothing goes to waste in a termite colony. Termites cannot digest lignin, a material that helps plants stay rigid. After it passes through their bodies, Formosans use it to fortify nest material and shelter tubes. Formosans also eat their dead, recycling nitrogen and protein.
- Termites in a colony engage in constant, repetitive grooming and feeding. They clean their nestmates' bodies and consume liquids that others regurgitate or excrete. This allows them to exchange food and microorganisms they depend on for digestion.
- Each colony includes a king and a queen who maintain their place at the pinnacle by emitting a substance called juvenile hormone. This hormone suppresses the sexual development of others and, depending on dosage, determines what track they follow: workers or soldiers and which are sterile or reproductive. The biggest doses of juvenile hormone produce soldiers.
- Termites depend on chemical signals and other sensations to guide their every step. A Formosan's plain, milky white body is actually an elaborate sensory apparatus, covered with tiny hair-like appendages called sensilla. Some feel, and some are specialized to detect chemicals that guide them in feeding, defense and reproduction.

LSU Ag Center gets patent on Formosan termite baits

A historic 150-year-old cotton warehouse on New Orleans' riverfront near the Garden District is the test site of a new patented bait system that holds promise of controlling the dreaded Formosan subterranean termite.

Gregg Henderson and Jian Chen of the LSU Agricultural Center developed the bait system that lures termites into a feeding chamber, then entices them into a second chamber that contains toxin-laced material the invaders carry back to their nest to kill the entire colony.

Henderson and Chen put out their first prototype bait stations Oct. 15, 1998. The apparatus is made from a plastic cylinder about 8 inches long and 4 inches in diameter. It is divided into two chambers by a wall with a small hole in the center.

The first chamber contains a small amount of cardboard as an introductory food source for the insect while a paper plug initially keeps termites out of the other section.

Because they do not know how easily a termite colony would find them on its own, the researchers placed termites in the non-toxic sections before they set them out.

Henderson's crew put about 30 of the devices around the warehouse near mud-walled shelter tubes the targeted termites build and use for travel between their colony and food sources.

"Putting the apparatus near a shelter tube is easier than trying to find the actual colony site, which may be deep beneath the ground or, in the case of Formosan termites, hidden behind building walls," Henderson said.

After these introduced termites feed on the cardboard, they should venture into nearby shelter tubes and lay down trails that termites in the targeted colony will follow back to the bait.

The trail that leads into the bait station is important.

"Termites make and follow chemical trails to and from their nests to find their way back again," Henderson said. "We hope we can take advantage of that to lure them to the toxicant."

Eventually, the termites will consume the cardboard and then the plug between the two chambers of the bait system, opening up the second side containing the insecticide-laced bait.

"We use two chambers to make sure the termites blaze a trail to the colony and back again before they consume the toxicant," Henderson said.

"The toxicant is a chitin inhibitor that affects the molting process of the termites, but it doesn't harm people because we don't have chitin, nor do we molt," Henderson said. "The paper bait is being manufactured and provided by Ensystex, the newest bait on the market."

Termite baits are slow-acting and may take about 6 months to effectively eliminate a problem, Henderson said. A cellulose-containing monitor can be used to measure consumption and termite activity and evaluate control.

Within six months from the start of the New Orleans study, Henderson expects to show significant control.

A termite colony can have a population from 500,000 to as many as10 million, he said. A quarter million termites can be killed with as little as 0.01 grams of active ingredient when it is provided in a bait formulation. ■ **Rick Bogren**

Termite detection system on its way to your home

Soon a typical home may include a termite detector as well as a smoke detector and carbon monoxide detector, thanks to Gregg Henderson and Jian Chen of the Department of Entomology and Roger Laine of the Department of Biochemistry.

"Most termite inspection starts with a technician in an attic or basement with a flashlight and a screwdriver or knife, poking at rafters and floor joists, looking for damage caused by termites," Henderson said. "By that time, a lot of damage may have been done."

Researchers have recently discovered that termites produce naphthalene, a hydrocarbon they apparently use as a defense against natural enemies, such as ants. The detection system, which was developed by the LSU Agricultural Center trio and has a patent pending, samples the air in the walls of a building and analyzes its composition. If the system identifies the chemicals associated with termites, there is a strong possibility they are there.

A homeowner's inability to actually detect termites rather than discover the results of their activities is a major obstacle in early termite control.

"It's our weakest link in fighting termites," Henderson said. "Currently, termites are found through indirect methods after they've already done significant damage."

This high-priority research in termite control was funded through the Louisiana Educational Quality Support Fund, a competitive grant program within the Louisiana State University system.

Henderson said the next step is full-scale testing.

"We're negotiating with a national laboratory to develop a device to apply the technology," Henderson said. "With an agreement in place, it would take about a year to evaluate the effectiveness and efficiency of the system."
■ **Rick Bogren**

Photo by John Wozniak

Weed management research in cotton with Staple, Roundup Ready and BXN systems

Donnie K. Miller, P. Roy Vidrine, Eddie P. Millhollon, Dearl E. Sanders, Daniel B. Reynolds, David L. Jordan and Christopher B. Corkern

Before 1996, farmers controlled weeds following cotton emergence almost exclusively by directing herbicides underneath the canopy to minimize injury to the cotton plant. For these postemergence, directed applications to be effective, there had to be sufficient height differences between the crop and the weeds and adequate rainfall or mechanical incorporation to activate residual components. Herbicides applied over the top of cotton often resulted in only fair weed control, delays in crop maturity and yield reductions.

In 1996, the commercial release of the herbicide pyrithiobac, sold under the trade name Staple, for postemergence application in cotton provided a means of obtaining excellent postemergence control of many broadleaf weeds while not injuring the crop. In addition, Staple provides preemergence, residual weed control through soil activity and has since received a label for application after planting.

Recent advances in plant biotechnology, allowing transfer of genes for herbicide tolerance to plants, have led to the development of herbicide-tolerant crops. Cotton varieties tolerant to herbicides glyphosate and bromoxynil, sold under the trade names Roundup Ultra and Buctril, respectively, are commercially available. Both provide postemergence control of a number of weeds in cotton. Questions about the utility of Staple, Roundup Ultra and Buctril compared with the traditional weed management systems have arisen. An overview of research results to date is presented.

Staple system

Staple provides optimum control when applied to small, actively growing weeds or when adequate rainfall is received for activation following soil application. Postemergence activity is slow, with chlorotic, or yellowing, symptoms visual within seven to 10 days. Susceptible weeds not killed are stunted, reducing competition with cotton and establishing required height differential for subsequent postemergence, directed applications.

Redroot pigweed, smooth pigweed and smartweed are extremely sensitive to Staple. Control of pitted, entireleaf and ivyleaf morningglory is good to excellent, with the latter two species being

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slightly more sensitive. Hemp sesbania control is good, with weed susceptibility increasing as growth progresses beyond the cotyledon to first true leaf stage. Staple provides good control of common cocklebur with optimum activity when applied before the two-leaf stage. Prickly sida control is fair to good if applications are made when weeds are no taller than 1 to 2 inches. Sicklepod control with Staple is fair to poor regardless of application timing. Staple provides suppression of small seedling grasses and nutsedge and little control of smellmellon, wild okra and copperleaf.

When applied before emergence, Staple provides good control of prickly sida and fair to poor control of morningglory species, hemp sesbania and common cocklebur. Addition of fluometuron is recommended for increased control of less susceptible species.

Staple programs can reduce the number of herbicide applications while maintaining optimum cotton yield. In trials comparing weed control systems, a program including postemergence application of Staple followed by one postemergence, directed treatment provided comparable control (more than 96 percent) of pigweed, pitted and entireleaf morningglory, common cocklebur, hemp sesbania and prickly sida and yield to a standard program which included three postemergence, directed applications. Because of limited activity on grass species and lower preemergence activity on problem broadleaf weeds, use of soil-applied residual herbicides was still needed to maximize weed control and yield in a Staple program.

Note that addition of postemergence grass herbicides to Staple has resulted in reduced johnsongrass control when compared to grass herbicides alone. A reduction in control was observed with combinations of Staple and Poast Plus, Fusilade 2000 or Select in studies conducted in Alexandria when adequate rainfall was received before and after application. In St. Joseph, however, reduced control was observed with addition of Assure II, Bugle, Fusilade 2000, Poast Plus or Select under low rainfall conditions.

Following Staple application, cotton plants occasionally have exhibited chlorosis, or yellowing, in terminal areas and a ragged appearance on leaf margins. These symptoms seem to be transient and have not caused serious yield reductions.

Roundup Ready system

Roundup Ultra has been extremely effective in controlling small, actively growing weeds. Like Staple, activity of Roundup Ultra is slow, with visual symptoms of damage not appearing until seven to 10 days after application. Roundup Ultra, at a single application rate of 1.5 pints per acre, exhibits good to excellent activity on barnyardgrass, crabgrass, goosegrass, broadleaf signalgrass, fall panicum, rhizome and seedling johnsongrass, smooth and redroot pigweed, sicklepod, spurge, common cocklebur, copperleaf, wild okra and wild poinsettia.

Fair to poor control of pitted morningglory, entireleaf and ivyleaf morningglory, hemp sesbania, prickly sida, velvetleaf and spurred anoda can be expected with a single application. Higher initial rates or sequential applications improve control.

> Because of lack of residual activity, sequential applications generally provide the most consistent weed control.

Research has shown that, because of lack of residual activity, sequential applications generally provide the most consistent weed control. The first application should be made when the initial flush of weeds reaches 1 to 3 inches in height. Sequential applications should follow 10 to 14 days later, preferably when weeds are not stressed.

The postemergence application window with Roundup Ultra is narrow because applications cannot be made over-the-top to cotton beyond the four-leaf stage, after which applications must be directed. Delaying the initial Roundup Ultra application, whether in a single or sequential program, beyond the 1- to 3-inch stage can result in longer competition among weeds and the crop and necessitate a higher rate of herbicide and possible interference with spray coverage.

Results from research evaluating the necessity of residual herbicides in a Roundup Ready program have been varied. In general, success of a total postemergence weed control program with Roundup Ultra is enhanced under drier conditions, which usually results in fewer weed flushes and allows more timely applications. Under these situations, sequential applications have provided weed control and yields comparable to programs that included a preemergence herbicide.

Hemp sesbania, morningglory, prickly sida and nutsedge have been shown to be less susceptible to Roundup Ultra, especially beyond the three- to four-leaf stage. Preemergence herbicides that control these weeds would be beneficial in increasing the overall performance of the Roundup Ready program and act as insurance in case adverse weather prevents timely postemergence application. Additionally, use of soil-applied herbicides may eliminate the need for a second Roundup application. Research to date has shown that use of residual herbicides may still be needed to produce maximum yields over a range of environmental conditions, especially on less susceptible weeds.

In a Roundup Ready weed control systems test in 1997, postemergence application of Roundup Ultra at 1.5 pints per acre (as needed but limited to two applications) following Prowl plus Cotoran preemergence at labeled rates produced 1,876 pounds per acre of seed cotton. Yield dropped to 1,210 pounds per acre when Cotoran was removed from the preemergence program. When Prowl was removed from the preemergence program, seed cotton yield was 1,703 pounds per acre. Plots receiving no preemergence treatment, Roundup Ultra postemergence application and Bladex late-directed application produced 1,842 pounds per acre of seed cotton.

In a conventional cotton production system test, plots receiving a preemergence application of Treflan pre-plant incorporated and Cotoran preemergence followed by Roundup Ultra outyielded plots receiving only Roundup Ultra by 853 pounds per acre. In stale seedbed and wheat cover crop production systems, plots receiving Roundup Ultra and no residual herbicide, although exhibiting good weed control 37 days after treatment, were heavily infested with weeds late in the season and were unharvestable.

The weakness of Roundup Ultra on several weed species, including hemp sesbania and morningglory, may be

Table 1. Comparison of Staple, Roundup Ready and BXN weed control systems in cotton.

	Staple	Roundup Ready	BXN
Technology Fee and/ or Seed Premium Assessment	No	Yes	Yes
Variety Restrictions	No[a]	Application only to varieties containing Roundup Ready gene	Application only to varieties containing the BXN gene
Application Timing[b]	Preemergence Postemergence (over-the-top) or postemergence directed beginning at first true leaf stage to 60 days before harvest	Postemergence (over-the-top) from ground-cracking stage through four-leaf stage Postemergence directed or hooded sprayer after four-leaf stage until layby Preharvest application after 20% boll crack	Postemergence (over-the-top) or postemergence directed from crop emergence to 75 days before harvest
Residual Weed Control	Yes	No	No
Rotational Crop Restrictions[c]	Yes	No	Yes
Weed Spectrum	Primarily broadleaf with suppression of annual grasses and nutsedge	Both grass and broadleaf	Strictly broadleaf

[a] greater injury potential observed with Pima varieties
[b]consult individual labels for maximum use rate and number of applications
[c]consult label for rotational intervals and precautions

overcome by tank mixtures with other herbicides. Limited research has shown that Staple, which has good morningglory and sesbania activity, may be an appropriate tank mix partner with Roundup Ultra.

BXN system

Buctril works quickly on susceptible weeds, with symptoms visible as soon as one day after application. Like the previous herbicides, maximum control is observed on actively growing weeds. Buctril provides good to excellent control of morningglory species, common cocklebur, hemp sesbania, Pennsylvania smartweed, wild okra and wild poinsettia. It provides fair control of small pigweed and prickly sida and little or no activity on sicklepod or grasses.

As with the Staple and Roundup Ready programs, use of the BXN system can reduce the number of postemergence, directed herbicide applications while maximizing yields. When evaluating weed control systems, a program consisting of Buctril applied postemergence followed by Bladex plus MSMA postemergence, directed resulted in weed control and seed cotton yield equivalent to programs including two postemergence, directed applications. Tank mixtures of Buctril and grass herbicides Assure II, Fusilade DX or Select reduced johnsongrass control when compared with the grass herbicides applied alone. The greatest antagonism was noted with Assure II and the least with Select. Buctril application one day before application of grass herbicides was generally more antagonistic than when applied one day after. In most cases, a three-day interval was sufficient to eliminate antagonism. Residual herbicides are needed to maximize weed control and cotton yield with the BXN system. Addition of Staple to Buctril applied postemergence or preceding Buctril as a preemergence treatment has been effective in increasing pigweed control in the BXN system.

Summary

Staple, Roundup Ready and BXN weed control systems offer advantages for control of certain problem weeds in Louisiana cotton. Staple offers freedom of variety selection, residual weed control and a wide application window. Disadvantages include higher herbicide necessitating banding (application to a certain percentage of the row) to reduce costs, limited grass activity and carryover potential to rotational crops. Roundup Ready offers broad spectrum control of both grasses and broadleaves, low herbicide cost (allowing broadcast applications) and lack of carryover potential to rotational crops. Weaknesses include lack of residual weed control, restriction to varieties containing the Roundup Ready gene, higher seed cost and technology fee, and a narrow window for postemergence application. The BXN system offers rapid activity on susceptible weeds, relatively low herbicide cost and minimal carryover concerns. Disadvantages include lack of residual weed control, no grass activity and restriction to varieties containing the BXN gene.

Added technology assessment fees and added cost in seed purchase for transgenic varieties, cost of herbicide programs, efficacy, agronomic characteristics and yield potential of varieties are all factors that should be considered in the decision to adapt these new weed control systems. ■

Acknowledgment
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Nutrient uptake of annual ryegrass grown in eight Louisiana soils

Bradley C. Venuto, Edward K. Twidwell and Jerry D. Ward

Annual ryegrass forage is grown on approximately 300,000 acres in Louisiana each year. It is planted over the entire state on widely diverse soils. Significant variation in ryegrass performance occurs among these diverse production areas, and reduced forage yields on some soils can limit the benefit of ryegrass for livestock producers. In addition, plant nutrient uptake is an important component of forage diet quality and is greatly affected by soil type and soil mineral status. The objectives of this study were to 1) evaluate variation in soil nutrient status among a wide range of soils where ryegrass is commonly grown, 2) evaluate relative dry matter yield production on these soils and 3) compare mineral uptake and relative livestock nutritional value of ryegrass grown on these soils.

Eight soils from annual ryegrass production sites were collected from throughout Louisiana with the aid of the Louisiana Cooperative Extension Service parish agents. The soils and the regions were: Ben Hur (Sharkey clay), Crowley (Vidrine silt-loam), Jennings (Crowley silt loam), Jonesboro (Bowie silt loam), Lafayette (Coteau silt loam), Many (Latonia silt loam), Rosepine (Guyton silt loam) and Ruston (Sacul-Bowie silt loam). Each soil was analyzed for pH, organic matter and macro and micro nutrients at the LSU Agricultural Center's Soil Testing Laboratory on campus.

> Mineral content of the ryegrass should be taken into account to make sure mineral deficiencies, excesses or imbalances do not occur in the dairy ration.

Greenhouse studies were designed to compare two annual ryegrass varieties, Gulf and Rio, grown on each soil for at least two months. The first greenhouse study was done in the spring of 1997, and the second was completed in the fall of 1997. Soils were completely unamended and received no nutrient applications during the studies.

Five ryegrass plants were established in each of seven containers for each soil type. The first test was seeded Feb. 16, 1997, and the second test was seeded Sept. 8, 1997. Dry matter yields were taken for ryegrass harvested from each container and averaged to provide yield values for each replication. Each test was harvested twice: test 1 on April 10, 1997, and May 16, 1997, and test 2 on Oct. 17, 1997, and Nov. 17, 1997. A composite of harvested plant material from all four replications for each variety and each soil type was made at each harvest and used for plant tissue analysis. Plant samples were analyzed for mineral content at the Forage Quality Laboratory at the Southeast Research Station in Franklinton.

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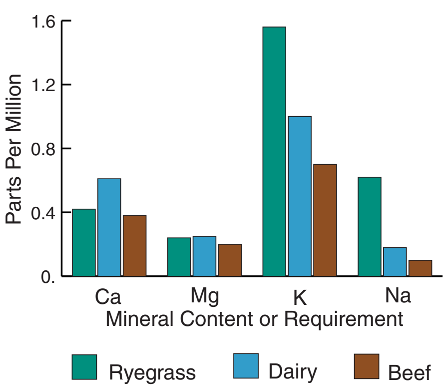
Table 1. Soil pH, organic matter, relative yield and mineral analysis for soil collected from eight locations in Louisiana.

Location	Yield*	pH	OM(%)	Ca	Mg	P	K	NA	Cu	Zn	Mn	Al
				ppm								
Ben Hur	80	5.4	0.68	1609	346	106	102	50	2.13	15.04	32	10
Crowley	187	4.4	0.28	342	136	16	27	83	0.46	0.29	56	166
Jennings	113	5.6	1.27	1375	231	150	75	28	1.87	25.5	44	3
Jonesboro	91	5.2	0.58	290	32	67	54	9	0.54	4.41	25	12
Lafayette	57	6.1	0.96	1125	106	30	96	20	1.18	4.63	82	2
Many	57	5.5	0.37	141	27	13	55	8	0.14	7.75	17	9
Rosepine	119	5.1	0.77	402	40	34	23	18	0.21	2.05	16	16
Ruston	91	6.5	1.44	1159	143	28	77	10	0.23	4.03	14	3
Mean	100	5.4	0.79	805	132	55	63	28	0.85	7.96	36	28

* Dry matter yield as a percent of the test mean.

The average values for yield, soil pH, organic matter and nutrient analysis for the eight soils are presented in Table 1. Yield was negatively correlated with potassium and pH, but it was positively correlated with sodium and aluminum. These results contrast with conventional wisdom and other research. The discrepancies are primarily the result of the Crowley soil, which had the highest aluminum and sodium content and the lowest pH. This soil, however, produced more than 1.5 times as much forage as the next closest soil. This indicates that some soil types in Louisiana deserve more research. It should be noted that these soils had no fertilizer added to them during this experiment, and more research is needed to determine the effects of fertilization on these soil types.

Figure 1. Average concentration of calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) in ryegrass forage grown on eight soils, compared to dietary need for a dairy or beef cow.



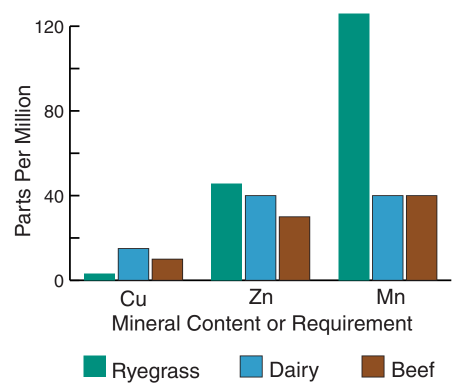
Significant differences in ryegrass yield performance and nutrient uptake were observed among soils, but there was no overall soil by variety interaction. Contrary to expectations, yields were positively correlated with aluminum levels and negatively correlated with pH. Mineral concentration in the harvested ryegrass varied significantly among soils but not between varieties. This research has implications for future efforts to develop site specific management strategies and to identify or develop varieties that perform well under less than ideal soil conditions.

The average mineral content of the ryegrass varieties grown on the eight soil types along with the recommended mineral concentrations for a lactating dairy and lactating beef cow diet are shown in Figures 1 and 2. None of the soils produced ryegrass with sufficient calcium to meet the requirements of a dairy cow, even though several of the soils had adequate to high soil levels of calcium. Two of the soils could not meet the calcium requirement of beef cows; one soil produced ryegrass that barely met the requirements of a beef cow. All of the soils had adequate magnesium for beef cows but only half provided adequate magnesium for dairy cows. All soils produced forage that met the requirement for zinc of beef cows but only six provided adequate zinc for dairy cattle. None of the soils produced ryegrass that contained enough copper to meet the requirements of beef or dairy cattle. All soils produced ryegrass with enough sodium and manganese to meet the requirements of both beef and dairy cattle, but there were large variations among the forages grown on the eight soils.

The differing amounts of mineral uptake by ryegrass among these eight soils would have profound effects on the required mineral supplementation programs needed while grazing these forages. The differences would have more of an impact for beef cattle grazing only ryegrass without mineral supplementation. Ryegrass grown on Jennings soil, however, would need to be supplemented only with trace mineralized salt to provide adequate trace minerals, assuming adequate phosphorus content.

Phosphorus uptake was not measured in this experiment because of the small sample of ryegrass available for analysis. Even though mineral analysis indicates adequate manganese and zinc content of the ryegrass produced on Jennings soil, some zinc and manganese should be added to the mineral supplement to provide a safety net. It is not well understood exactly how much of the trace minerals found in forages are available for use by ruminants. Research is under way in the Louisiana Agricultural Experiment Station to answer that question.

Figure 2. Average concentration of copper (Cu), zinc (Zn) and manganese (Mn) in ryegrass forage grown on eight soils, compared to dietary need for a dairy or beef cow.



The differences in mineral concentration in ryegrass would have less impact on the mineral supplementation programs of dairy cattle because ryegrass rarely contributes more than half the intake of dairy cattle and frequently provides less than 10 percent of the diet, especially in once-a-day grazing systems. The results of this study indicate that forage mineral content can be highly variable. Therefore, the mineral content of the ryegrass should be taken into account to make sure mineral deficiencies, excesses or imbalances do not occur in the dairy ration. ■

Delayed phytotoxicity syndrome of rice

Donald E. Groth, Dearl E. Sanders and Greg Rich

Rice plants showing herbicide damage where no herbicides had been applied for several weeks were first found in 1991 in southwest Louisiana. Symptoms included stunting, excessive tillering, curvature or "fishhooking" of tillers, dark green color, stem brittleness and plant death. Areas with damaged plants were irregularly shaped and unevenly distributed within fields, which suggested a biological cause. Symptoms were similar to those caused by high rates of the herbicide rice molinate (Ordram), but soil analysis for molinate showed none.

Affected acreage increased to nearly 20,000 acres in 1993. A similar problem had been reported in Japan during the mid-1970s and was associated with dechlorination of herbicides containing a chlorinated benzene ring by an unidentified facultative anaerobic bacterium.

In the United States, the problem has been termed Delayed Phytotoxicity Syndrome (DPS) and has been associated with the several rice herbicides. These herbicides have halogenated aromatic compounds as their active ingredient and include thiobencarb (Bolero), quinclorac (Facet), triclopyr (Grandstand), propanil and 2,4-D, both available commercially in various formulations.

Fungi cause the problem

To determine if dechlorination of halogenated herbicides and DPS are directly related, a greenhouse experiment using the white mold fungus *Phanerochaete chrysosporium*, which is known to dechlorinate aromatic rings, was conducted. The procedure involved

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Photo by Dearl E. Sanders

Areas with plants damaged because of DPS are irregularly shaped and unevenly distributed within fields.

incorporating the fungus into sterile soil in the presence and absence of thiobencarb, transplanting four-leaf rice seedlings into the soil and flooding the pots. Separate experiments were conducted with quinclorac and triclopyr. Plants were then monitored for DPS symptoms.

At the same time, rice plants were transplanted into a conducive soil from a field exhibiting DPS that was treated with thiobencarb. When plants began showing symptoms, a soil sample was collected from under the plant, and various microorganisms were isolated. These microorganisms were purified and then tested for their ability to dechlorinate thiobencarb using a bioassay in sterile soil. Soil from the white mold/ thiobencarb experiment was tested in an analytical testing lab for dechlorinated thiobencarb.

It was shown that the white mold fungus was able to dechlorinate thiobencarb based on symptoms and the presence of dechlorinated thiobencarb in the soil. Quinclorac and triclopyr also were dechlorinated, based on symptom development, but symptoms were not as severe. Two fungi and one bacterium were isolated from the conducive soil and identified as having the ability to dechlorinate thiobencarb.

Fungicides offer cure

Since fungi were involved, experiments were conducted to determine if fungicides could be used to control the problem. Soil from a field exhibiting thiobencarb-induced DPS was placed in pots in the greenhouse. Thiobencarb was applied to the soil, and then fungicides were applied. Pots were then flooded, and four-leaf rice seedlings were transplanted into the soil. Treatments included an untreated check, thiobencarb at 4 pounds active ingredient per acre, benomyl (Benlate) and iprodione (Rovral) fungicides used at 2 pounds active ingredient per acre, and a herbicide and fungicide combination. Plants were monitored for DPS symptoms.

The experiment was repeated in the field in the conducive soil. Treatments included the fungicides impregnated separately onto the 10 G formulation of thiobencarb and onto blank granules. In field experiments, the soil was prepared for water seeding, and galvanized steel rings were placed in the field to stop herbicide movement in the soil or water. A preplant surface application of thiobencarb was made, and presprouted seeds were water-planted 48 hours after herbicide application. Water was temporarily drained for 24 hours after seeding to allow seedling attachment to the soil. Plots were monitored for DPS development. The experiment was repeated using similar methods but using the liquid formulations of thiobencarb and sequential applications of the fungicides after the herbicide.

Severe injury developed 30 days after treatment on greenhouse plants where thiobencarb was applied alone. No injury was apparent in the untreated check, fungicides only and thiobencarb plus fungicide treatments. Iprodione and benomyl were the most effective, and iprodione had more residual activity.

Seven days after herbicide application in the field, there was a 95 percent stand loss with thiobencarb alone. Granular thiobencarb plus iprodione resulted in a 2 percent stand loss. Similar results were noted 30 days later. In comparison, thiobencarb plus benomyl plots had 28 percent stand loss after seven days and a 91 percent stand loss after 30 days. The untreated checks and the fungicide alone showed no injury. Weed control was not affected by the addition of the fungicide to the herbicide. A close association of the herbicide and fungicide was necessary since sequential sprays with the liquid herbicide and fungicides were less effective than tank mixes.

Photo by Dearl E. Sanders

Symptoms of delayed phytotoxicity syndrome include stunting, excessive tillering, curvature or "fishhooking" of tillers, dark green color, stem brittleness and plant death. Both plants have the symptoms.

Control limited to draining fields

Currently, the only control for DPS is to drain rice fields and permit the soil to dry. This allows the soil to become oxygenated and causes the dechlorinated herbicide, which is apparently unstable in aerobic conditions, to break down. Draining causes other problems, however, including nitrogen loss and more susceptibility to weeds and diseases.

Th DPS problem appeared right after the U.S. Environmental Protection Agency banned use of fungicide-treated seed in 1990. Although use of fungicides is preventive, it is not legal at this time. Further work is being done to obtain a label for the use of fungicides against DPS and to determine the most cost-effective fungicide. ■

Acknowledgment

The authors would like to express their appreciation to Valent U.S.A. Corp. and the Louisiana Rice Research Board for providing funds to support this research.

Sorghum midge management in Northeast Louisiana

Evaluation of plant resistance, insecticide treatment and planting date

Boris A. Castro, Thomas J. Riley and B. Roger Leonard

Photo by Jerry Lenhard

Figure 1. The adult midge is a small, red, gnat-like fly about 1.5 millimeters long.

Photo by Thomas J. Riley

Figure 2. Damage is caused by the larva, which feeds inside developing sorghum seeds, eating the seed as it develops.

The sorghum midge is a key pest of grain sorghum in the United States and can cause serious yield losses in Louisiana. The adult midge is a small, red, gnat-like fly about 1.5 millimeters long (Figure 1). Damage is caused by the larva, which feeds inside developing sorghum seeds, eating the seed as it develops (Figure 2). Female midges lay eggs only in sorghum that is flowering (Figure 3). Although a female midge lives only one day, she can lay between 50 and 250 eggs. The sorghum midge spends the winter as a pre-pupa in sorghum crop residue or in johnsongrass, its natural wild-host plant (Figure 4).

Sorghum fields are susceptible to the sorghum midge only when the plants in the field are in flower. Flowering sorghum is recognized by the presence of fresh, yellow pollen on the sorghum head (Figure 3). Individual sorghum plants usually flower over three or four days, but sorghum fields can have plants in flower for several days to weeks, depending on the uniformity of field and environmental conditions that determine the rate of plant growth and development. Damage from the sorghum midge is not apparent until the seed heads mature. Sorghum heads heavily damaged by the sorghum midge are called "blasted" heads and have brown areas where no seeds have developed (Figure 5).

Sorghum midge integrated pest management (IPM) efforts in Louisiana rely on several practices. These include:

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- uniform, early planting dates
- hybrid selection for similarity in maturity dates
- avoidance of planting in fields near johnsongrass
- destruction of crop residue
- insecticide applications

Timing of insecticide applications is critical to a successful sorghum midge IPM program. Insecticides must be applied to coincide with the flowering of sorghum fields. Differences in planting dates, hybrid maturity and environmental conditions, however, can cause many fields to flower non-uniformly, preventing insecticides and other recommended strategies from providing the level of control necessary for profitable sorghum yields.

Plant resistance techniques can be successfully used for sorghum midge management. Considerable progress has been made in the development of

Photo by Thomas J. Riley

Figure 3. Female midges lay eggs only in sorghum that is flowering.

Photo by Thomas J. Riley

Figure 4. The sorghum midge spends the winter as a pre-pupa in sorghum crop residue or in johnsongrass, its natural wild-host plant.

Photo by Boris A. Castro

Figure 5. Sorghum heads heavily damaged by the sorghum midge are called "blasted" heads and have brown areas where no seeds have developed.

experimental sorghum hybrids that are biologically resistant or can tolerate infestation by the sorghum midge. These hybrids suffer less damage under equivalent infestation conditions and maintain acceptable yields. Although commercial availability of resistant sorghum hybrids is limited, our studies were conducted to evaluate how plant resistance technology can be integrated into local management strategies to increase the efficiency of sorghum midge IPM in Louisiana.

Photo by Boris A. Castro

Undamaged heads of grain sorghum.

Solving the problem

Experiments were conducted in 1994 and 1995 at the Macon Ridge branch of the Northeast Research Station in Winnsboro. DeKalb DK60, a commercially available sorghum hybrid with resistance to the midge, and a commercial hybrid susceptible to the sorghum midge, Delta and Pine Land DPL1552, were compared at four planting dates in mid-March, mid-April, mid-May and mid-June. The April and May planting dates were chosen to represent the recommended range for planting grain sorghum in Louisiana.

Each planting date was split into two subplots. One subplot was treated with the insecticide chlorpyrifos at 0.5 pound per acre at three-day intervals while the subplot was in flower. No insecticide was applied to the other subplot at any time during the experiments.

At the time of these studies, DK60 was the only commercially available sorghum hybrid with some degree of sorghum midge resistance. It is a relatively tight-headed hybrid and may not be suitable to all parts of Louisiana. The research design included 16 treatment plots replicated four times. Plots were 12.2 meters long and consisted of 16 rows per main planting date, eight rows per insecticide treatment and four rows per hybrid.

Sorghum midge populations were measured twice each week when sorghum plants were flowering by counting the midges on each of 20 flowering sorghum heads per plot. Sorghum midge damage was assessed by estimating the percentage of blasted kernels on each of 50 sorghum heads selected at random from the two center rows of each plot. Yields were obtained by mechanically harvesting the two center rows of each plot.

Photo by Thomas J. Riley

Damaged or "blasted" head on left and undamaged head on right.

What we found

Sorghum midge numbers

Sorghum midge numbers varied significantly throughout the flowering period from June to August. When sorghum midge populations were low, more sorghum midges were found in susceptible DPL1552 than in the resistant hybrid DK60 (Figure 6). The highest numbers were observed during the first half of August and coincided with the period when sorghum plants from the mid-June planting date were flowering. When susceptible DPL1552 and resistant DK60 sorghum were compared over the entire growing season, the number of sorghum midges in the susceptible sorghum was generally higher than the number in the midge resistant sorghum (Figure 6).

Sorghum midge populations increased from June to August. In susceptible sorghum DPL1552, the economic threshold level of one sorghum midge per sorghum head was exceeded in early July 1994 and in late June 1995. In resistant sorghum DK60, the economic threshold level (ETL) of five midge per sorghum head was exceeded only at the end of the flowering period (Sept. 2) in 1994 and in early August 1995 (Figure 6). Under these conditions, resistant hybrid DK60 received less damage from the sorghum midge in 1994 and in 1995.

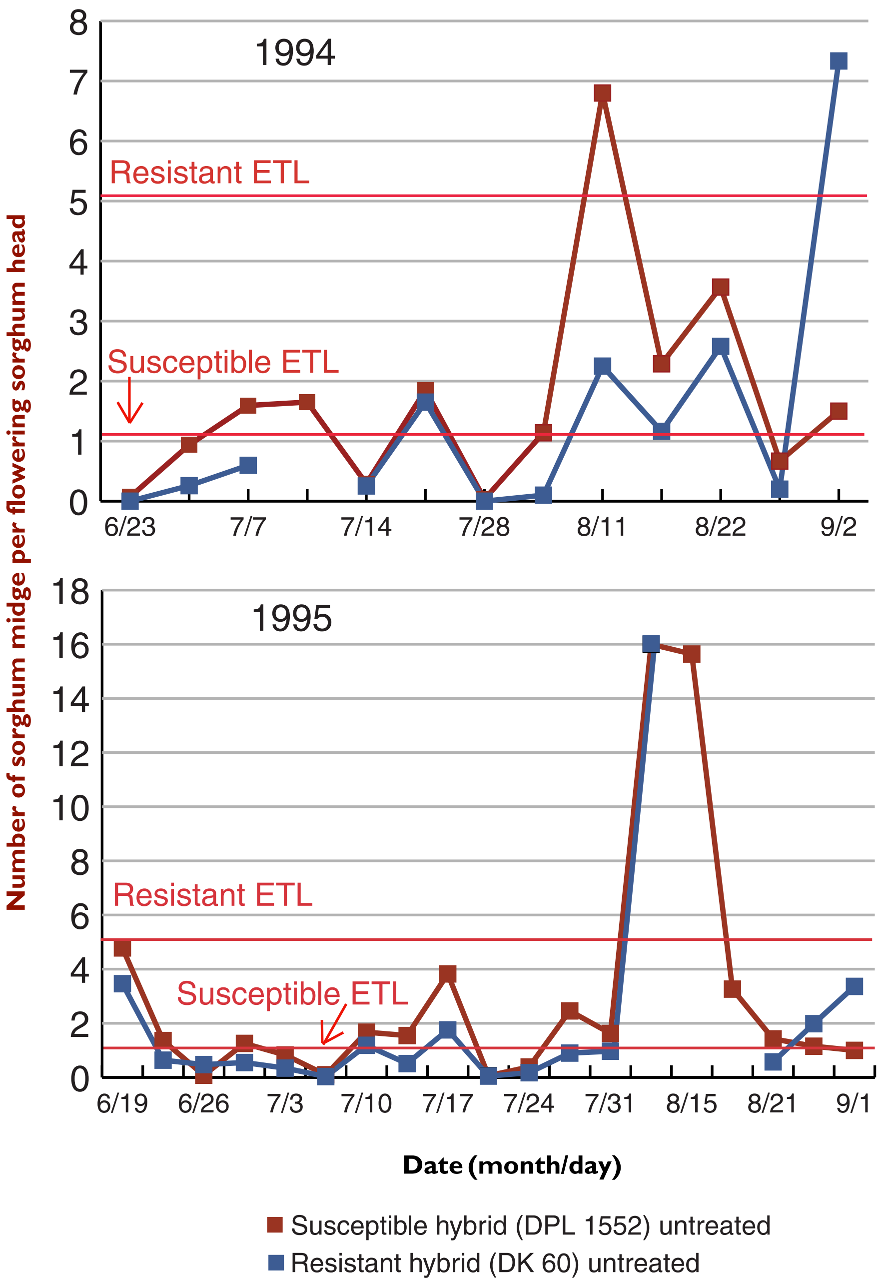
Sorghum midge damage

In our experiments, resistant hybrid DK60 received less damage from the sorghum midge in all four planting dates in 1994 and 1995. When considered with the number of sorghum midge found in each hybrid, our experiments suggest that the significant differences in damage in 1994 and 1995, and yields in 1994, resulted from the preference of female sorghum midges to lay eggs on the susceptible hybrid.

Yields

Resistant hybrid DK60 yielded significantly higher than susceptible DPL1552 during 1994, but not during 1995. In 1995, both hybrids

Figure 6. Observed abundance of sorghum midge per flowering sorghum head in 1994 and 1995.



yielded highest when planted in mid-April and mid-May. In 1994, yields for mid-April and mid-May also were high, and a slightly higher yield for the resistant DK60 occurred in the mid-June planting. Yields of susceptible hybrid DPL1552 were reduced when planted in mid-June. No yield differences were observed in resistant DK60 across all planting dates in 1994.

In 1995, the lowest yields were obtained in both hybrids when planted in mid-June. This yield reduction was because of severe drought stress during sorghum grain fill that year. Hot weather and low moisture during grain fill are known to kill sorghum midge pupae. In our experiments, survival of developing midges was probably reduced by the hot, dry weather experienced during grain fill in 1995. This would explain why reduced sorghum midge damage was observed in the mid-June planted sorghum in 1995, even though it was exposed to numbers of ovipositing sorghum midges that exceeded economic thresholds (Figure 6).

Insecticide effects

Sorghum treated with insecticide when plants were blooming also had significantly less damage from the sorghum midge than untreated sorghum in 1994 and 1995. Sorghum yields were significantly improved with the use of an insecticide in 1994 and 1995. It is important to note that in our experiments untreated resistant DK60 experienced less damage and demonstrated the potential to produce yields comparable to the susceptible hybrid DPL1552 that was treated with insecticide to control the sorghum midge.

What it means to Louisiana sorghum producers

- Commercially available sorghum hybrid DeKalb DK60 successfully demonstrated resistance to the sorghum midge under northeast Louisiana conditions.
- The economic threshold level of five midge per head, developed for resistant hybrids, was not exceeded until much later in the growing season, compared to the economic threshold level of one midge per head for susceptible hybrids. This delayed or eliminated the need to apply insecticides to control the sorghum midge in the resistant hybrid.
- Yields in the resistant hybrid, when not treated with insecticide, can be comparable to those in the susceptible hybrid treated with insecticide to control sorghum midge.

Our studies indicate that plant resistance to the sorghum midge has potential as an integrated pest management tool for Louisiana. As more sorghum hybrids become available with sorghum midge resistance, sorghum growers should be able to realize greater profitability by maintaining yields equivalent to those of locally adapted susceptible hybrids but with less cost because of reduced need for insecticides to control the sorghum midge. ■

Acknowledgments

We thank Dr. A. Bruce Maunder of DeKalb Plant Genetics at Lubbock, Texas, for providing seed of DeKalb DK60 and the Louisiana Soybean and Feed Grain, Research and Promotion Board for providing partial funding for this research.

Effects of duration of flowering in grain sorghum on sorghum midge damage

Because the sorghum midge depends on flowering sorghum to lay its eggs, understanding how the length of the flowering period affects damage can aid in developing more effective programs to manage this key insect pest.

In experiments conducted during 1994 and 1995 at the Macon Ridge Branch of the Northeast Research Station near Winnsboro, higher sorghum midge damage occurred with extended blooming periods. We used two hybrids: DeKalb DK60, a commercially available sorghum hybrid with tolerance to the midge, and a commercial sorghum midge susceptible hybrid, Delta and Pine Land DPL1552. Both sorghum hybrids were planted at four planting dates: early (mid-March), two planting dates within the recommended range for Louisiana (mid-April and mid-May) and a late planting date (mid-June).

Within each hybrid, 1,600 plants were randomly selected and labeled. The number of days each plant was in the yellow-bloom stage was determined by counting the days from the beginning of yellow bloom until the last day that yellow pollen was present on the sorghum head. Also, the number of days to reach half-bloom, which is the time when one-half of the plants in a field are in the yellow-bloom stage, was calculated from the date of planting to the date that half of the selected plants were in yellow-bloom. Midge population density and midge damage to sorghum panicles were determined also.

Half-bloom in sorghum planted in mid-June was reached in significantly fewer days compared to the other planting dates. Also, the late-planted sorghum experienced a significantly shorter blooming period compared to all other planting dates. Unexpectedly, sorghum midge damage in both years was highest in sorghum planted in mid-March.

Our research suggests the prolonged flowering period in early-planted sorghum caused this to occur. Sorghum from the mid-March planting flowered under low sorghum midge pressure, but it was exposed and available for midge oviposition 1.4 times longer than sorghum in the mid-April and mid-May plantings, and 2.1 times longer than sorghum planted in mid-June. Consequently, damage from the sorghum midge was higher and seed yields were lower in early-planted (mid-March) sorghum.

Traditional recommendations for planting sorghum have been to plant early to avoid the high sorghum midge populations that occur later in the season, but planting too early or an unusually cool spring and early summer could prolong flowering, exposing sorghum to the midge over an extended period.

The length of the flowering period observed in the resistant (DK60) hybrid was significantly shorter (12 days) than flowering period in the susceptible (DPL1552) hybrid (15 days). The shorter flowering period in the resistant hybrid may have conferred additional protection from ovipositing midges compared to the susceptible hybrid.

Our results stress the importance of the flowering period to an integrated pest management program (IPM) for the sorghum midge. The length of time that plants in a sorghum field are in flower affects the field's vulnerability to sorghum midge. Fields with lengthy flowering periods may require extending spraying with insecticides to protect against midge damage. Hybrids with consistently short, uniform flowering periods will be less susceptible to egg laying and subsequent damage from sorghum midge. This information helps in understanding the characteristics that make sorghum plants susceptible to the sorghum midge and is useful for implementing an IPM program for grain sorghum in Louisiana.

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New blueberry variety shows promise for expanding production in Louisiana

Blueberry production contributes to the local economies of several Louisiana communities, particularly in the northwest and southeast areas of the state. In 1997, blueberry production added $1.5 million to the state's economy. More than 500 acres of blueberries are grown in the state, and this acreage has been increasing in the last five years. The most widely grown variety is called Rabbiteye. It produces a high quality fruit marketable from mid-June to mid-July.

A new variety called Southern Highbush, however, shows promise for the state. It is a hybrid of Rabbiteye and Northern Highbush, a popular variety grown in Michigan, the No. 1 blueberry-producing state. We are conducting research on Southern Highbush in an effort to help its introduction here. If accepted, it will expand the growing season and thus the market. The Southern Highbush matures early and is available in early May. It blooms late, which improves its chances of escaping late spring frosts.

For more than 60 years, blueberry growers have realized that cross-pollination is necessary for good marketable yield. The blueberry flower is not designed for efficient self-pollination. To enhance pollination, every fourth row of blueberry bushes must be a different variety. Our research focuses on optimizing cross-pollination.

Charles E. Johnson, Professor, and Yuehe Huang, Post-Doctoral Researcher, Department of Horticulture, LSU Agricultural Center, Baton Rouge, La.

Beef cattle graze on a ryegrass-cereal rye pasture. Photo by Sidney M. DeRouen

Impact of prepared seedbeds and bermudagrass sods on performance of annual ryegrass and cereal rye

Marcus M. Eichhorn Jr. and Bradley C. Venuto

In the Coastal Plain of north Louisiana, pastures of annual ryegrass and cereal rye, alone or in combination, are made in late summer and fall to reduce dairy and beef cattle winter supplemental ration requirements and to enhance overall herd performance. Prepared seedbeds are planted to provide grazing on the earliest possible date. Bermudagrass sods are planted later, when competition from sods for soil moisture and plant nutrients is at lowest levels.

Because information was limited on the comparative performances of annual ryegrass and cereal rye plantings made in prepared seedbeds and bermudagrass sods, a study was conducted at the Hill Farm Research Station. The objectives were to determine the relative annual yield performances of annual ryegrass and cereal rye when planted alone or in combination into either a prepared seedbed or bermudagrass sod and to provide useful information to the Louisiana Cooperative Extension

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Service for making recommendations to livestock producers that will optimize forage production from their intended fall plantings.

Materials and methods

Experiments were conducted for three consecutive growing seasons, 1994-95 through 1996-97, with Marshall annual ryegrass and Maton cereal rye. Each year, starter fertilizer at 600 pounds of 4-16-32 ($N-P_2O_5-K_2O$) per acre was broadcast on the soil surface and incorporated to a 3-inch depth before planting seed in prepared seedbeds.

On Coastal bermudagrass sods, starter fertilizer at a similar rate also was broadcast on the surface after all standing forage was cut to a 2-inch stubble height and removed from the area intended for planting. Marshall ryegrass and Maton rye seeding rates were 30 pounds and 90 pounds per acre, respectively, when planted alone or in combination. When planted alone in prepared seedbeds, ryegrass and cereal rye seed were drill-planted at 1/2-inch and 1-inch soil depth, respectively. Planted in combination, cereal rye seed was drill-planted and ryegrass seed was broadcast afterward on the surface of plots. For plantings made in Coastal bermudagrass sods, ryegrass seed was broadcast on the surface of plots when planted alone or after the cereal rye seed was sod-seeded. Cereal rye was sod-seeded at a 1-inch soil depth when planted alone or in combination with annual ryegrass. Averaged across years, prepared seedbeds were planted on October 5, and Coastal bermudagrass sods were planted on October 19.

Post-establishment fertilization practices and harvest frequencies were similar each year for prepared seedbeds and bermudagrass sods. Fertilizer, 30-0-0-8 ($N-P_2O_5-K_2O-S$) at 300 pounds per acre, was broadcast on the surface of the plots in mid-November, and fertilizer, 17-5-20-5 at 588 pounds per acre, was applied after the February and March harvests. Mean harvest dates across years were December 10, January 10, February 6, March 6, April 5 and May 18.

Results and discussion

Planting methods had a considerable effect on annual ryegrass and cereal rye forage production (Table 1). When data were subjected to contrast analysis, from December to March, drill-planted annual ryegrass in prepared seedbeds out-yielded broadcast-seeded plantings on bermudagrass sod. Drill-planted cereal rye in prepared seedbeds out-yielded sod-seeded cereal rye for most of the late fall and winter growing season. Drill-planted cereal rye over-seeded with annual ryegrass on prepared seedbeds produced higher forage yields throughout the growing season than sod-seeded cereal rye over-seeded with annual ryegrass. Across all planting methods (broadcast, drill-seeded and sod-seeded) and seedbeds (prepared and bermudagrass sod), yields for annual ryegrass and cereal rye were greatest during March and April.

Across the growing season, drill-planted annual ryegrass on prepared seedbeds out-yielded broadcast plantings on bermudagrass sods by about 50 percent. Because mature beef and dairy cattle require about 25 pounds of forage dry matter per day for maintenance, establishing ryegrass on prepared seedbeds had the potential to provide an additional 86 days of animal grazing. Yield for drill-planted cereal rye in prepared seedbed was not different from sod-seeded cereal rye. Both methods of establishing cereal rye had the potential to provide an average 184 days of grazing.

Where annual ryegrass seed was broadcast over drill-planted cereal rye in prepared seedbeds, the yield was 50 percent higher than that of annual ryegrass seed broadcast on sod-seeded cereal rye. Potential for grazing was 99 days longer for ryegrass and cereal rye established in the prepared seedbed. Across all planting methods and seedbeds, drill-planted cereal rye in a prepared seedbed over-seeded with a broadcast application of annual ryegrass seed provided highest forage yield with highest potential animal days of grazing.

These findings will be helpful to livestock producers across the Coastal Plain of north Louisiana who intend to plant annual ryegrass and cereal rye, alone or in combination, in the fall into either prepared seedbeds or bermudagrass sods. Cereal rye-ryegrass mixtures on prepared seedbeds will provide the most forage. ■

Table 1. Three-year mean forage yields of Marshall annual ryegrass (RG) and Maton cereal rye (CR) alone and in combination (RG+CR) as influenced by planting methods on prepared seedbeds (PPSB) and Coastal bermudagrass sods (BSOD), 1994-97.

Forage crop	Seed bed+	10 Dec	10 Jun	6 Feb	6 Mar	5 Apr	28 Apr	13 May	Total
		Harvest dates							
		Dry forage, lb/acre							
RG	PPSB	134	220	561	705	1607	1582	1257	6062b*
RG	BSOD	0	28	81	195	668	1721	1230	3920d
CR	PPSB	326	284	583	1156	1407	595	571	4921c
CR	BSOD	0	422	306	742	1204	791	837	4305cd
RG+CR	PPSB	615	522	943	1179	1631	1444	1038	7371a
RG+CR	BSOD	0	380	501	791	1155	1276	791	4893cd
	Mean	179F	309E	496D	795C	1279A	1235A	954B	

*Values having a common lower case letter within a column or upper case letter within a row are not different at the 95% level of probability.
+RG-PPSB = RG seed drill-planted in PPSB, 7-inch spaced rows; RG-BSOD = RG seed broadcast on surface of BSOD; CR-PPSB = CR seed drill-planted in PPSB, 7-inch spaced rows; CR-BSOD = CR seed sod-seeded in BSOD, 13-inch spaced rows; RG+CR-PPSB = CR seed drill-planted in PPSB, 7-inch spaced rows and RG seed broadcast on surface; RGCR-BSOD = CR seed sod-seeded in BSOD, 13-inch spaced rows and RG seed broadcast on surface.

At-planting insecticide treatments provide thrips control in cotton and allow earlier harvest

Donald R. Cook, Eugene "Gene" Burris, B. Roger Leonard and Jerry B. Graves

Thrips are early season insect pests of cotton in Louisiana. Injury to cotton seedlings resulting from thrips' feeding can delay crop maturity and reduce yields. Delayed crop maturity can further expose the crop to damaging infestations of late-season insects and adverse environmental conditions that hinder defoliation and harvest. These environmental conditions can reduce lint quality and yield. Timely application of fall agronomic practices necessary to the following year's crop also may be delayed.

Evaluating treatments

Stoneville 474 cotton seed was planted at both locations of the Northeast Research Station in early May in both 1996 and 1997. These trials were planted on a Commerce silt loam and Sharkey clay soils at the St. Joseph location and on a Gigger silt loam soil at the Winnsboro location.

The insecticides in these trials included Orthene 80S (6.4 ounces of active ingredient per hundredweight seed) and Gaucho 3.84S (4.0 ounces of active ingredient per hundredweight seed) applied as seed protectants, Orthene 90S (0.9 pound of active ingredient per acre) and Admire 2F (0.2 pound

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Table 1. Effect of at-planting insecticide applications on maturity, first harvest yield and final yield of cotton across soil environments in 1996 and 1997.

Treatment	Rate/acre lb (AI)	Application method[1]	Percent first harvest	Lint yield (lb/acre) first harvest	Final lint yield (lb/acre)
1996					
Orthene 80S	6.4[2]	SP	83.9b	1248a	1483
Gaucho 3.84S	4.0[2]	SP	84.4ab	1279a	1506
Orthene 90S	0.9	IFSAP	84.0b	1277a	1517
Admire 2F	0.2	IFSAP	85.9a	1309a	1521
Temik 15G	0.5	IFGAP	85.4ab	1292a	1511
Untreated	___	___	78.3c	1147b	1463
(P > F)			>0.01	0.02	0.80
1997					
Orthene 80S	6.4[2]	SP	91.9a	1122a	1215
Gaucho 480S	4.0[2]	SP	91.0a	1071ab	1171
Orthene 90S	0.9	IFSAP	89.7a	1001bc	1113
Admire 2F	0.2	IFSAP	90.0a	1108ab	1221
Temik 15G	0.5	IFGAP	90.1a	1071ab	1175
Untreated	___	___	84.9b	948c	1089
(P > F)			0.02	0.04	0.18

Means within columns for each year followed by a common letter are not significantly different (P=0.05;FPLSD).
[1] SP = Seed Protectant, IFSAP = In-Furrow Spray At-Planting, IFGAP = In-Furrow Granule At-Planting.
[2] oz AI/cwt seed.

of active ingredient per acre) sprayed in the seed furrow, Temik 15G (0.5 pound of active ingredient per acre) as a granule in the seed furrow and an untreated control.

Control of thrips was measured by randomly selecting five plants per plot at 7, 11, 15, 19, 23 and 27 days after emergence in 1996 and at 7, 11, 16, 19, 23, 27, 31 and 35 days after emergence in 1997. Plant samples were processed using whole plant washing procedures to remove insects. These data for individual sample dates were pooled to determine treatment effects across the entire sampling period.

All treatments provided control

At the Sharkey clay site, plots treated with Orthene 80S, Orthene 90S, Admire or Temik had significantly fewer total thrips (adult plus immature insects) compared to plots treated with Gaucho or the untreated plots in 1996 (Figure 1). In 1997, plots treated with Orthene 80S, Gaucho or Temik had significantly lower numbers of thrips compared to plots treated with Admire or the untreated plots.

At the Gigger silt loam site, all insecticide treatments significantly reduced thrips numbers compared to those in the untreated plots in 1996 (Figure 2). In 1997, plots treated with Temik had significantly lower numbers of thrips compared to plots treated with Orthene 90S, Orthene 80S, Gaucho or the untreated plots.

At the Commerce silt loam site, all insecticide treatments significantly reduced the numbers of total thrips compared to the untreated control in 1996 and 1997 (Figure 3).

In 1996, all insecticide treatments significantly reduced days to defoliation and harvest and increased the percentage of first harvest compared to the untreated control across soil environments. In 1997, all insecticide treatments significantly improved crop maturity compared to the untreated control. At first harvest, all insecticide treatments resulted in significantly more lint yield compared to the untreated plots in both 1996 and 1997. There were no significant differences among treatments for final lint yield in 1996 or 1997 (Table 1). Although there were no significant differences observed for final yield, crop maturity was delayed in the un-treated plots.

All insecticide treatments provided satisfactory control of thrips in all three soil environments, with few exceptions. Also, these insecticide treatments resulted in an earlier maturing crop and higher yields at first harvest. These benefits would allow producers to harvest earlier and avoid inclement fall weather and late-season insect infestations. ■

Acknowledgments

The authors wish to thank the summer field personnel at both locations of the Northeast Research Station, as well as Karen Williams and Ralph Sheppard for their assistance in data collection, plot maintenance and pesticide application. Also, the authors wish to thank Cotton Incorporated and Louisiana cotton producers for their financial support of this project.

Figure 1. Efficacy of at-planting insecticides against thrips at the Sharkey clay site in 1996 and 1997. Analysis and mean separation for total thrips within each year.

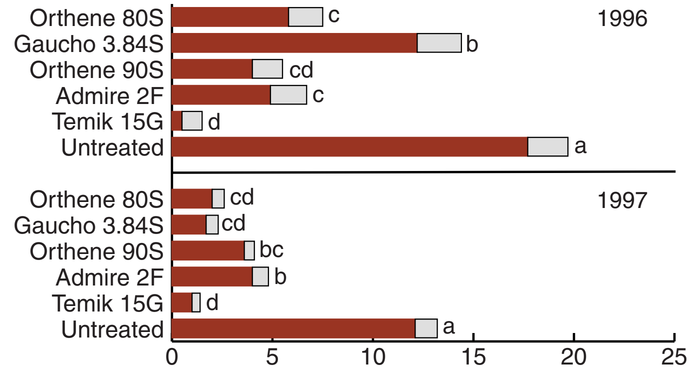


Figure 2. Efficacy of at-planting insecticides against thrips at the Gigger silt loam site in 1996 and 1997. Analysis and mean separation for total thrips within each year.

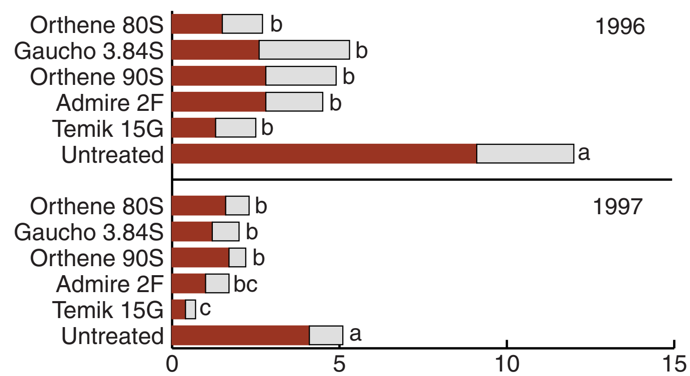
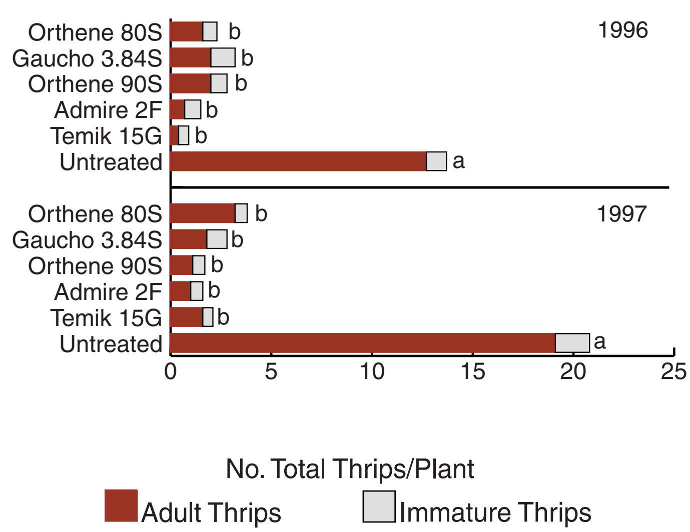


Figure 3. Efficacy of at-planting insecticides against thrips at the Commerce silt loam site in 1996 and 1997. Analysis and mean separation for total thrips within each year.



Evaluating soybean varieties for late planting in Louisiana

James E. Board, David Y. Lanclos, James Rabb and Bobby G. Harville

Planting soybeans after June 15 is a major production problem in Louisiana. For every day that planting is delayed after June 15, a soybean farmer can expect to lose an average of a half bushel of yield. Yet, farmers continue to do this for a variety of reasons. We have no accurate figures for how many farmers plant soybeans late. But we know the practice represents a substantial annual financial loss of tens of millions of dollars to our state.

The most common reason for late planting of soybeans is adverse weather. Weather conditions from May 1 to June 15, the optimal planting period for most varieties, may be too wet or too dry. Other reasons for late planting include double cropping after wheat, a delay in receiving a crop loan, a late-season rise in soybean prices or the farmer is preoccupied with other crops before attending to soybean planting.

Cultural recommendations for increasing late-planted soybean yield include reducing row spacing to 20 inches or less, increasing plant population above the level recommended for optimal planting dates and alleviating any environmental stress, such as from drought or water logging. Irrigation systems will alleviate drought stress. Grading fields to allow for drainage, eliminating uneven spots and adding ditches around fields can alleviate water logging.

Another way to increase yield at late planting dates is proper varietal selection. Because varietal rankings are not consistent between optimal and late planting dates, farmers cannot rely on information from the statewide soybean variety trials to determine what to plant. The objective of this research is to provide soybean producers with varietal recommendations specifically for late planting.

Our study involved 46 soybean varieties selected from the statewide trials and representing Maturity Groups V, VI and VII. Soybeans are classified into maturity groups based on the length of time needed to reach harvest maturity after planting. The higher the Roman numeral, the longer it takes for the soybean to reach harvest maturity. The varieties were planted at Baton Rouge on July 7, 1995, and July 2, 1996, in a randomized complete block experimental design with four replications. A companion variety study, consisting of 15 varieties selected from the 46 varieties grown at Baton Rouge, also was conducted in 1996 at the Red River Research Station at Bossier City in northwest Louisiana. We did this to determine if yield rankings between Baton Rouge and Bossier City were similar.

In addition, in both Baton Rouge studies, we collected data on plant dry weight at the start of seed fill and the length of the seed filling period. These additional data, along with plant height, were used in a regression equation for predicting yield. Our purpose was to compare actual and predicted yield to determine the accuracy of the regression equation. If accurate, the regression equation would provide us with a much faster and efficient method for identifying high-yielding varieties and lines at late planting dates. Such a tool would be useful in breeding programs aimed at developing varieties with improved yield at late plantings.

Averaged across 1995 and 1996, yields in the late-planted variety trial at Baton Rouge ranged from a low of 43 bushels per acre for TV5452 (Maturity Group V) to a high of 62 bushels per acre for Dyna-gro 3682 (Maturity Group VII). Based on these results, a farmer could potentially increase yield by 44 percent by choosing the proper variety.

Using the guideline developed for the statewide variety trials (that recommended varieties are those yielding within 90 percent of the average yield of the top three varieties), 11 of the 46 varieties were recommended (Table 1). Most of the recommended varieties were from Maturity Group VII, supporting the recommendation that the best-yielding varieties for late planting are those with longer growing periods. Three Maturity Group VI varieties, however, also were recommended: P9692, HBK67 and H6686.

Table 1. Yields of recommended varieties planted at a late date near Baton Rouge, averaged over 1995 and 1996.

Variety (Maturity Group)	Yield (Bu/A)
Dyna-gro 3682 (VII)	62
NKS75-55 (VII)	61
Stonewall (VII)	61
H7550 (VII)	60
Haskell (VII)	60
P9692 (VI)	59
HBK 67 (VI)	58
HYP 798 (VII)	58
P9671 (VII)	57
HYP 741 (VII)	56
H6686 (VI)	56

Yields in the Bossier City study ranged from 35 to 57 bushels per acre (Table 2). Surprisingly, the best-yielding variety in this study was A5885 (Maturity Group V). Yield rankings between Baton Rouge and Bossier City were not similar. Some of the highest-yielding varieties at Bossier City (A5885 and DP3627) had modest yields at Baton Rouge, and some recommended varieties at Baton Rouge (Dyna-gro 3682 and NKS75-55) gave intermediate yields at Bossier City.

The general superiority of Maturity Group VII varieties at Baton Rouge did not occur at Bossier City. Although yield rankings from Baton Rouge can be extrapolated to other areas of southern Louisiana, these results indicate they cannot be extrapolated to northern Louisiana. Separate late-planted variety trials will have to be conducted in northern Louisiana to identify recommended varieties for that region.

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Comparison of actual and predicted yields indicated that the regression equation, based on crop dry weight at the start of seed filling, plant height and length of the seed filling period, provided an accurate estimation of yield. In 70 percent of comparisons, predicted yields were within 6 percent of actual yields. The regression equation identified three of the four top-yielding varieties. Since the parameters entered into the regression equation are easy to obtain and can be determined in small one-row plots, the regression equation has potential for rapidly identifying high-yielding varieties or lines for late-planted production. We will do more work with this regression model. ■

Acknowledgment
The authors express appreciation to the Louisiana Soybean and Grain Research and Promotion Board for providing funds to help support this research.

Table 2. Comparison of varietal yield rankings for Baton Rouge and Bossier City for late-planted soybeans, 1996.

BATON ROUGE		BOSSIER CITY	
Variety (MG)	Yield Bu/A	Variety (MG)	Yield Bu/A
Dyna-gro 3682 (VII)	62	A5885 (V)	57
NKS75-55 (VII)	61	Stonewall (VII)	56
Stonewall (VII)	61	DP3627 (VI)	54
Haskell (VII)	60	Haskell (VII)	52
P9692 (VI)	59	NKS62-66 (VI)	52
DP3627 (VI)	51	DP3733 (VII)	52
DP3733 (VII)	51	Brim (VI)	50
A5885 (V)	51	Dyna-gro 3682 (VII)	49
NKS62-66 (VI)	50	P9692 (VI)	47
RVS 757 (VII)	50	TV6253 (VI)	45
NKS59-60 (V)	46	NKS75-55 (VII)	41
TV6253 (VI)	44	NKS59-60	41
Brim (VI)	43	RVS 757 (VII)	39
TV5452 (V)	43	TV5452 (V)	35

Precision seeders for vegetables: *How precise are they?*

Regina P. Bracy, Richard L. Parish and Joe McCoy

Establishing a full stand of field-grown plants is necessary for high yields of vegetables. Unfortunately, the grower cannot always control factors that hurt stand establishment, such as soil crusting, temperature extremes and excessive soil moisture. The grower, however, can minimize or overcome the effects of climatic and biotic factors by using the proper seeder.

Seed spacing uniformity and seed placement depth are important for an adequate and uniform stand and are directly affected by seeder performance. In several studies, researchers at the Hammond Research Station evaluated the seeding uniformity of precision vegetable seeders and the effects of seed coverers, presswheels and seeding depth on stand establishment of several vegetable crops.

Seeder uniformity

Two types of precision vegetable seeders, belt and vacuum, were evaluated for seeding uniformity with the seeds of five vegetable crops. The crops represented a range of seed shapes: spherical or nearly spherical (cabbage and onion), angular (spinach) and elongated and flat (carrot and cucumber). The seeders were operated over a board 6 inches wide and 20 feet long coated with grease to prevent seed bouncing and to retain exact placement of the seed. Seed spacings were recorded.

The belt seeder did an effective job of uniformly seeding spherical (cabbage) and nearly spherical (onion) seed. Although the vacuum seeders did a better job with elongated seed (carrot and cucumber) than the belt seeder, none of the seeders did an adequate job of spacing cucumber and carrot seed uniformly. Seeding uniformity of all seeders with spinach seed also was insufficient.

Overall, the belt seeder was the most uniform and precise of the seeders tested. Seeding uniformity of the belt seeder was good when seeding spherical and nearly spherical seed. When seeding elongated or angular seed with the belt seeder, multiple seed drops and reduced seed spacing uniformity should be expected.

Seed coverers and presswheels

Although several types of seed covers and presswheels are available from precision seeder manufacturers, the effects of covering devices and presswheels on plant emergence of directly seeded cole crops have not been determined. Ten experiments were conducted at the station during spring and fall. Planting times and field locations were varied to assess planter component performance under different soil moisture conditions and texture.

A Stanhay belt seeder was equipped with combinations of four covering devices and four rear presswheels for a total of 16 treatments. Covering devices included standard drag (0.6-inch-square steel bar), light drag (0.4-inch-square steel bar), paired arms (0.2-inch by 1.2-

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Photo by Mark Claesgens

Photo by Mark Claesgens

On the left is a standard smooth presswheel with a paired arm covering device. At right are three other types of presswheels, left to right, the concave split, the flat split and the cage.

inch steel paddles) and no covering device.

Presswheels included standard smooth steel banded (4.5-inch wide by 9.0-inch diameter), concave split (3.5-inch wide by 10.8-inch overall diameter with 0.5-inch space between conical wheels), flat split (4.5-inch wide by 9.0-inch diameter with 1-inch space between wheels) and cage (4.5-inch wide by 9-inch diameter covered with expanded steel mesh). All presswheels and covering devices, except the light drag, are stock parts available with the Stanhay seeder. The light drag covering device, a replica of the standard drag with a smaller drag bar, was constructed in the university's shop. Growers would be able to replicate this.

Savannah or Florida Broadleaf mustard was planted using a single-line belt and single-line opener with a seed spacing of 2.7 inches or 3.3 inches. Asgrow XPH 5957 cabbage was planted using a single-line belt and single-line opener with a 3.3-inch seed spacing.

At the March, April, August and October planting dates, soil moisture was optimum for seeding. Soil moisture at the November planting was not conducive for optimum seed covering.

All plantings received at least 0.6 inches of precipitation within three days after planting, which is adequate moisture for germination and growth. Heavy rainfall (7.8 inches) occurred within three days of the October planting.

All the covering devices and presswheels evaluated were adequate for mustard and cabbage under soil moisture conditions and soil type found in these plantings. Uniform plant emergence with all covering devices and presswheels was attributed to adequate rainfall within three days of planting that effectively closed the seed furrows after planting. Different results may be found if planting in heavier soil type, under drier or wetter soil conditions, or if precipitation does not occur within a few days after planting. We observed that the paired arms device did the best job of covering, and we have switched to this at the station. Operating the seeder without a covering device, regardless of presswheel attached, left the seed furrow open and seed exposed.

Seeding depth and opener type

Seeding depth affects stand establishment. A common recommendation is to place seed at a depth equal to three times its diameter. With small seeds, such as mustard and cabbage, however, this recommendation results in planting so shallow that heavy rainfall soon after planting can wash away soil covering the seed. Also, a dry soil surface will limit moisture to the seed planted at a depth too shallow. Both of these problems can be alleviated by altering seeding depth.

We planted three vegetables, mustard, turnip and cabbage, at depths of 0.2 inch, 0.5 inch, 0.7inch and 1.0 inch with a Stanhay belt seeder in April, August and October 1997.

We also evaluated two types of openers, the two-line coulter opener and the scatter shoe opener. On these same dates, we planted mustard and turnip with a Stanhay belt seeder equipped with a two-line coulter opener and with a Gaspardo vacuum seeder equipped with a scatter shoe opener. The coulter opener distributed the seed into two small individual furrows spaced 2 inches apart. With the scatter shoe opener, the seed were dropped through a pattern of steel pegs that scattered the seed randomly over a 3-inch-wide furrow.

Soil moisture at the April planting was adequate. Soil moisture at the August and October planting dates was low, but adequate rain fell within five days of planting.

Seed emergence was not consistently affected by seeding depth under the optimum soil moisture conditions experienced in these studies. Overall, planting at depths of more than 0.5 inch was not detrimental to plant emergence. We recommend planting depths of 0.5 inch to 1.0 inch for small seeds, such as mustard, turnip and cabbage, to protect against seed washout from torrential rains and to provide better seed placement in soil moisture under drought conditions.

Plant emergence at all planting dates was greater in plots seeded using the 2-line opener than those seeded using the scatter shoe. The problem observed with the scatter shoe was the opener/coverer interaction. The scatter shoe opened a broad furrow and scattered seed randomly over the furrow bottom. The standard drag coverer then dragged a wave of soil over the furrow, and this soil wave appeared to displace some of the seed. Inconsistent depth control of the opener itself was another problem observed with the Gaspardo seeder. ■

A leg up for the chicken industry

Dipping and washing mince from broiler dark meat

Henri K. Salman, Kenneth W. McMillin and A. James Farr

Although a valuable source of protein and other nutrients, chicken leg meat is underused in the U.S. market. It is less desirable to consumers and more difficult to remove from the bone than breast meat.

Mechanical deboners can efficiently separate the meat from bone as a mince. This mince can then be used in the food industry for products such as chicken nuggets and frankfurters. But mechanical deboners incorporate air during the process that may initiate the oxidation of lipid and pigment components more so in dark chicken muscle than in breast meat. This can accelerate rancidity and discoloration.

This research was conducted to examine the process of dipping the leg quarters in two different antioxidants to determine if this resulted in a more satisfactory product. This research also evaluated the effect of washing the recovered mince on the quality of chicken patties.

Twenty-pound batches of leg quarters were soaked in either a solution of 1 percent citric acid or 1 percent mixed phosphate for 20 minutes. One batch was left unsoaked to serve as the control. The soaked leg quarters were ground through a 1-inch plate before being mechanically separated. The unsoaked leg quarters were hand deboned and then the meat was ground. Half of the mechanically separated or hand-deboned mince was washed in three successive solutions that included tap water and sodium bicarbonate. Following each wash, the mince was centrifuged to remove excess water. The lipid components that separated from the mince during centrifugation were removed by pumping the fat layer from the surface of the mince.

The washed and unwashed mince was cooled to 34 degrees F and formed into round quarter-pound patties. Patties were wrapped in plastic bags and stored at 40 degrees F for zero, three or seven days. Raw patties and cooked patties were evaluated for oxidative stability and color.

Raw patties from unwashed, recovered mince had 21 percent less moisture and 9 percent to 16 percent more fat than washed mince from each treatment. Soaking in citric acid or phosphates decreased the moisture and protein and increased the fat content compared with hand-deboned leg meat.

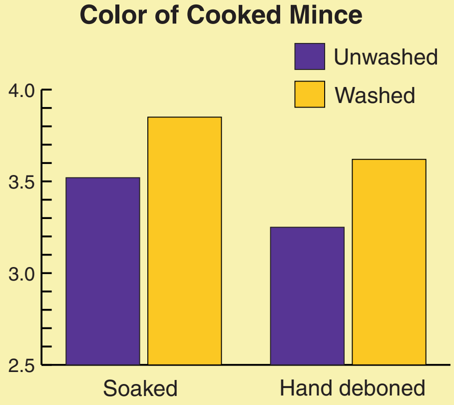
The color of the recovered mince was darker, redder and yellower than that of hand-deboned meat. Washing the mince or meat removed some of the pigment, lightening the color to a less red and more yellow hue compared with unwashed mince or meat.

Cooking of patties caused the color to be darker, less red and more yellow than raw patties. Removal of the pigment by washing reduced the lipid oxidation. Cooking loss was less in washed mince than unwashed mince and in the hand-deboned meat compared with mechanically recovered mince.

The results indicated that washing provides a mince with more desirable color and oxidative properties while not greatly altering the texture of cooked patties compared with unwashed mince. The pre-deboning antioxidant soaking treatments were not effective in stabilizing the mince during storage, so alternative ingredients or processing will need to be studied to prevent lipid oxidation in mechanically separated mince.

Value-added and deboned meat products are primarily responsible for the increased per capita consumption and the availability of more convenient poultry products. Mechanical recovery of dark broiler meat from chicken hindquarters is more efficient than hand deboning, but more testing needs to be done on products to determine the amount of mince that can be added to whole muscle patties or nuggets for a desirable product. More research will help ensure that meat products for consumers are acceptable, high quality and nutritious. ■

Figure 1. Cooked color was evaluated with a reflectance spectrophotometer. Washing provided both the hand-deboned meat and mechanically deboned mince with a more desirable color.



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LSU animal physiology reproduction program turns 25

Photo by Mark Claesgens

Alumni of the LSU Ag Center's reproductive physiology program gathered for a reunion in October 1998 to celebrate the 25th anniversary of the program. They nicknamed themselves the "Repro Rangers."

Helping farm animals have babies efficiently and at the least cost to livestock producers has been the overall goal of the LSU Agricultural Center's reproductive physiology research program, which celebrates its 25th anniversary this year.

But along the way, this research program, established in 1973 under the direction of Robert Godke, has gained worldwide recognition for its contributions to the development of assisted reproductive techniques.

"The picture was very different 25 years ago than it is today," Godke said. "We had artificial insemination as a tool and were beginning work with embryo transfer."

Today, both artificial insemination and embryo transfer are widely used. Newer tools include cryopreservation, which means freezing embryos for later use, and *in vitro* fertilization, which means fertilization in a test tube or on a dish under a microscope.

Godke and his graduate students have played a major role in bringing about the practical use of all of these techniques. In the mid-1970s, his program, along with others, helped perfect non-surgical techniques for transferring embryos into surrogate mothers. Their original work was with cattle, but they have since developed procedures for sheep, goats, pigs and, most recently, horses.

Another milestone for the program was embryo splitting, which produces genetically identical twin animals from a single embryo. In 1982, researchers in the program produced their first sets of identical twin calves, or clones, using this technique.

One of the newest assisted reproduction procedures is called ICSI, or intracytoplasmic sperm injection. With this approach, a tiny pipette is used under a microscope to inject a sperm into an egg, or oocyte.

One of Godke's Ph.D. students, Richard Cochran, worked for two years perfecting ICSI in horses. He had his first success this past July with the birth of a foal. The birth was a milestone because he had non-surgically extracted the oocytes from a live mare and then used ICSI to create viable embryos that were then implanted in surrogate mares.

"Horses are more of a challenge for assisted reproductive techniques than other animals, such as cattle and sheep," Cochran said. "The biological makeup of horses makes all of the procedures more difficult."

Cochran is one of a dozen graduate students studying under Godke. His program has produced 51 master's theses or Ph.D. dissertations over the last 25 years.

"Some of our students did both their master's and Ph.D. research in our program," said Godke, who in 1995 was named an LSU Boyd professor, a recognition of teaching and research excellence.

He attributes his program's success to the dedication of the students, who have come from all over the world.

"The program is hard. I knew if I could survive it, I could survive anything. I gained confidence," said Lilly Zhang, originally from China who came from Cornell University in New York to study with Godke and is now laboratory director of a human infertility clinic in Dallas, Texas.

She is an example of graduates working with humans instead of farm animals.

"Many of the techniques I learned in working with animals also apply to humans," said Kim Morgan, who earned her master's degree in the program and is now an embryologist at Woman's Hospital in Baton Rouge, La.

■ **Linda Foster Benedict**

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