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**UofA**  
UNIVERSITY OF ARKANSAS  
DIVISION OF AGRICULTURE

FACULTY IMPACT STATEMENTS 2007

AAES, Division of Agriculture

# Faculty Impact Statements 2007



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ARKANSAS AGRICULTURAL EXPERIMENT STATION  
Division of Agriculture University of Arkansas System  
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## *Faculty Accomplishments Solve Problems and Create Opportunity*

Faculty accomplishments that help solve problems and create opportunity are reported in this collection of 2007 impact statements.

Some of these success stories represent many years of work; some are about programs just underway that hold the promise of future benefits.

The simple format of stating an issue, the action taken to address the issue, and the impact or benefits of the work provides easy-to-read success stories.

These impact statements and those from recent years are on the College and Experiment Station Web sites at:

<http://arkansasagnews.uark.edu/394.htm>



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# Competitive Agricultural Systems in a Global Economy

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## Animal Systems

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### **Divergent selection for pale, soft, and exudative-like (PSE-like) meat in broilers**

#### **Issue**

Increased selection for body weight, breast meat yield, and FCR in broilers has led to a number of metabolic disorders including the development of pale, soft, exudative (PSE-like) meat. This PSE-like meat is a result of accelerated post mortem glycolysis that results in paler meat, decreased water holding capacity, increased drip loss, and a decreased ability to form gels. With the increase in the demand for further processed ready-to-eat broiler breast products, this metabolic disorder can have large economic impacts. Although the incidence of PSE can vary dramatically in broiler flocks, it is estimated that PSE-like meat could cost a single processing plant \$4.4 million per year in lost product. This large economic impact has caused PSE-like meat to become an important issue in commercial broiler selection programs.

#### **Action**

Determination of PSE-like poultry meat can be accomplished through several techniques which include but are not limited to muscle color (L-value), post mortem muscle pH, and drip loss. Muscle pH is an excellent tool in the prediction of PSE-like poultry meat but has limitations associated with cost and assay time. These factors limit its application to commercial broiler selection programs. Muscle color as measured through the use of a colorimeter is relatively inexpensive and can produce real-time data in the processing plant. L-value has been shown to be highly correlated both phenotypically and genotypically with muscle color. The high genetic correlations suggest that these two traits may be under similar genetic control. In addition, moderate genotypic and phenotypic correlations have been reported between L-value and drip loss.

The heritability of L-value in broilers has been estimated to be as high as 0.55%. This high heritability suggests that direct selection for this trait could have the potential for rapid modification of muscle color in broilers. This, combined with the association of L-value with both muscle pH and drip loss, suggests that selection for increased L-value could lead to the development of broilers with an increased incidence of PSE-like meat. Thus, divergent selection for pale, soft, and exudative-like (PSE-like) meat in broilers was accomplished through selection for 24-hour L-value in broilers from the HOG-1 RBC population grown to 42 days of age. Selection was based on sire family means for 24-hour L-value in breast meat resulting in the development of two

lines selected for either increased 24-hr L-value or decreased 24-hr L-value. Analysis shows that the divergent lines differ in color by an average of 3 L\* units after only 3 generations of divergent selection.

#### **Impact**

The impact of the data generated from these lines is multifactorial. One, these data will determine if L-value as measured with a colorimeter can be applied as a real-time selection tool for the measurement of and ultimately the selection against PSE-like meat in commercial broiler populations. Second, the development of divergent populations allows for the further study of the underlying genetic and environmental factors that lead to PSE-like meat. As previously mentioned, the incidence of PSE-like meat varies in commercial broiler populations. It is also difficult to induce on a repeatable basis, thus making it difficult to study both the environmental and genetic factors leading to this disorder. Therefore, divergent lines that have either an increased or decreased susceptibility to PSE-like meat serve as more adequate models for the further development of our understanding of both the genetic and environmental causes of this disorder.

Elucidation of the genetic cause for PSE-like meat in commercial broilers would serve as a permanent solution to its incidence. However this change would not occur rapidly as it takes 4 to 5 years for changes on the pedigree level of a commercial selection program to reach the commercial broiler level. But an understanding of environmental factors resulting in PSE-like meat could lead to the savings of tens of millions of dollars through the application of precautionary management techniques prior to slaughter, until a permanent genetic solution can be reached.

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#### **Funding**

Division of Agriculture, University of Arkansas

### **Genomic SNP analysis differentiates ascites susceptible from resistant broilers**

#### **Issue**

Ascites syndrome in broilers represents the terminal consequence of an initial increase in blood pressure within the pulmonary circulation followed by fluid accumulation in the abdominal cavity. The economic loss due to ascites has



been estimated at one hundred million dollars per year in the United States. In 2002, it was estimated that 8% of the 361 million broiler deaths each year could be attributed to ascites. Direct economic costs include losses due to on-farm mortality, mortality during transportation to the processing plant, and condemnations at the processing plant. In fact, 0.05% of all processing plant condemnations are attributed to ascites. Indirect economic costs are associated with nutrition and management strategies that successfully reduce the incidence of ascites by reducing metabolic oxygen demand. These strategies prevent broiler producers from fully realizing the profit potential available genetically in modern broilers which, under ideal circumstances, are inherently capable of extremely fast growth coupled with excellent feed efficiency.

#### **Action**

Fourteen generations of divergent selection for ascites incidence have been applied to a commercial broiler line by the University of Arkansas Division of Agriculture. Specific mating combinations between the selected lines were generated and reared as a means to collect phenotypic data and blood/ DNA samples. Tail analysis was applied and those birds known to be extremely resistant or susceptible to ascites were further analyzed using Single Nucleotide Polymorphism (SNP) analysis. A total of 3,300 SNPs were genotyped. Data analysis resulted in the identification of at least 9 chromosomal regions, each containing four or more consecutive SNPs, which were highly related ( $p < 0.001$ ) to ascites susceptibility. Our goal is to further understand the genetic basis for ascites, which will likely aid in candidate gene identification. Once genes are identified we will determine the degree of relationship with correlated traits of economic importance.

#### **Impact**

These data will allow for the development of genetic tests that predict ascites susceptibility and resistance. Identification of such candidate genes could lead to a significant reduction/ permanent elimination of ascites in commercial broiler populations. Of course marker-assisted selection must proceed with caution. Ascites incidence has accumulated in commercial poultry populations that have been derived from a variety of genetic bases. Therefore, ascites incidence is likely linked with traits of economic importance such as breast yield, feed conversion, rapid growth, and BW at specific ages. Successful application of ascites markers will result in the breaking of linkage groups in critical chromosome regions impacting typical production traits focused on in primary poultry-breeding programs and incidence of ascites.

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#### **Funding**

Cobb Vantress; Arkansas Biosciences Institute; Division of Agriculture, University of Arkansas

### **Impact of diet and feeding program on growth and yield of commercial pheasants**

#### **Issue**

Because of the increasing acceptance and demand for pheasant products in the national and international markets, there has been a substantial shift from processing hunt birds to that of weight-selected high-yielding birds. Such selection has resulted in a shift from processing at a mature age of 20 weeks to a more juvenile age of 15 weeks. Since birds are being processed at younger ages, they are less aggressive and perhaps more malleable to higher density rearing without concomitant increases in carcass damage.

#### **Action**

A study was conducted to titrate the rearing density of weight-selected commercial pheasants. For this study, commercial pheasants were raised at densities of 2.0 sq ft per bird (standard industry density), 1.8, 1.6, 1.4, 1.2, and 1.0 sq ft per bird. In comparison, the commercial broiler chicken of today is reared at densities below 0.8 sq ft per bird. The impact of crowding was monitored by analyzing the growth and feed conversion of the commercial pheasant from hatch to 15 weeks of age. At the end of the 15-week period, the pheasants were processed to determine the impact of density environment on traits of economic importance such as breast and leg yield.

#### **Impact**

This study will result in changes in fundamental methods of rearing pheasants. Currently, commercial pheasants are reared at 2.0 sq ft per bird. If it is shown that rearing at higher densities does not have a negative impact on feed conversion, growth, and yield, then the pheasant industry has the opportunity to increase the number of birds currently produced per house. This will instantly allow for more efficient utilization of available facilities and utilities. Thus, as the processed pheasant market expands, the need for additional housing will be reduced. In addition to the \$250 thousand per house savings in construction of new facilities would be the reduced cold-season fuel usage associated with the generation of bird heat. These savings would far exceed the additional cost of improved ventilation in high-density rearing environments.

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#### **Funding**

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Division of Agriculture, University of Arkansas

## Acid enhancement of dark-cutting beef improves fresh and cooked color characteristics

### Issue

Dark-cutting (DC) beef is an economically relevant quality defect characterized by a pH value of 6.0 or higher, a shady dark-red to almost black lean color, a firm, “sticky” texture, and a very high water-holding capacity. More importantly, approximately 2 to 5% of the cattle slaughtered annually will produce DC beef, and it has been estimated that DC beef costs the American beef industry between \$170 to \$750 million each year. Typically, DC beef is used as manufacturing beef or exported at substantial discounts because of its dark, unattractive fresh color and its persistent *raw*, internal cooked color, even when cooked to temperatures of 162°F (“medium” degree of doneness) or higher.

### Action

In a series of experiments, beef strip loins (IMPS #180) from DC carcasses (ultimate pH values ranging from 6.5 to 6.9) were purchased from commercial beef packing plants and subsequently enhanced with solutions containing between 0.25 and 2.00% lactic acid (LA). After LA-enhancement, steaks were cut from enhanced DC strip loins, non-enhanced normal pH strip loins (ultimate pH values ranging from 5.4 to 5.7), and non-enhanced DC strip loins. Fresh steaks were either overwrapped in an oxygen-permeable, PVC film or packaged in a high-oxygen modified atmosphere before subsection to a 5-d simulated retail display. Additionally, all steaks were cooked to an internal temperature of 162°F before a trained sensory panel evaluated cooked beef color.

### Impact

Enhancing DC strip loins with solutions containing 0.25 to 0.50% LA effectively improved fresh and cooked beef color similar to that of normal pH, low-Choice beef. More importantly, the bright red fresh color formed by enhancing DC beef with LA was more stable across a typical 5-d display period than the fresh color of normal pH beef, and professional attribute panelists failed to detect any differences in flavor profiles when LA-enhanced beef was compared to normal-pH beef. Thus, the results of this series of experiments indicate that LA enhancement improves the fresh and cooked quality attributes of DC beef, which can lead to new marketing strategies for the red meat industry and reductions/elimination of the steep economic discounts associated with this quality defect that are received by today’s cattle producers.

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## Effect of establishment method and stocking rate on performance of calves grazing small-grain pasture

### Issue

In the fall and early spring, small-grain pastures have been used extensively to improve net-farm income in the High Plains. This improved net income comes from the availability of high-quality forage at a time of year when it is usually scarce and the availability of weaned calves at a seasonally low price. Because of this, the performance of calves during the fall is essential to enterprise profitability. It is natural to maximize stocking rates during this time to increase the number of calves purchased in this time frame.

Establishment of small-grain crops has traditionally involved intensive tillage techniques. Increased costs of equipment, fuel, and labor have raised questions about whether conventional-tillage methods of production are the best option. No-tillage techniques can maintain soil moisture and improve seedling establishment when precipitation is lacking. This research was conducted to determine the effect of fall stocking rate of small-grain pastures established using conventional, reduced, and no-till techniques on animal performance during the fall and subsequent spring.

### Action

Soft red winter wheat was sown in the first week of September. In November, sixty spring-born steer calves were placed on small-grain pastures at stocking rates of 0.75, 1.00, or 1.50 steers per acre. These steers grazed until early or mid-February, depending on forage availability. From 28 February to early April, 180 steer calves were placed on pastures at a stocking rate of 3 steers per acre. Daily gains were not affected by tillage method in the fall, but body weight gain per calf decreased from 317 to 227 lbs with increasing stocking rate. On pastures that were stocked heaviest in the fall, spring average daily gain and total body weight gain per calf were greater for conventional and no-till compared to reduced tillage methods. Over the entire fall and spring grazing periods, total body weight gain per acre was not affected by tillage method or stocking rate.

### Impact

This research indicates that no-till establishment of small-grain forage is a sound alternative to conventional tillage systems. Regardless of establishment method, individual animal performance during the fall is reduced with increasing stocking rate. Pastures established by no-till or conventional methods can be stocked at 1.50 calves per acre during the fall with minimal impact on spring performance. Two changes would occur in Arkansas if cost-effective, profitable, and environmentally sound methods of winter small-grain production could be developed and adopted. First, adoption of reduced tillage or no-till cropping systems would reduce the net cost of establishing small-grain pasture through reduced fuel, equipment, and labor inputs. This may allow many small cow/calf farms to begin planting

some acreage in winter small grains with the objective of retaining ownership of calves through the feeder stage. Second, the firmer footing and enhanced planting flexibility made possible with residue-preserving cropping methods of no-till and minimum tillage would open up thousands of additional acres of wheat for grazing in addition to grain harvest and also alleviate many environmental concerns.

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#### Funding

USDA NRI Managed Ecosystems program grant number 2005-35101-15344; Division of Agriculture, University of Arkansas

### Level of cottonseed cake supplementation for beef calves fed tall fescue hay

#### Issue

Increasing costs of fossil fuels and current federal energy policies that emphasize renewable energy sources have led to the increase in cost of the primary feedstuffs used to raise beef cattle. Increased grain prices have led to the reduction in acreage of wheat planted for pasture for growing cattle. The increased production of biofuels has also led to the increased availability of alternative by-product feeds that have the potential to provide safe, nutritious, and economical supplements for beef production. Cottonseed cake was once a popular protein supplement for beef cattle that is seeing resurgence in availability through the extraction of oils from cottonseed for use in biodiesel production. The cottonseed cake is commonly 33% crude protein and 70% in total digestible nutrients and may contain 7 to 10% fat. This research was conducted to determine the effect of increasing level of cottonseed cake supplementation on the performance of growing beef calves fed tall fescue hay.

#### Action

Forty-eight steers were placed into 6 dry-lot pens, offered tall fescue hay (13.9% crude protein and 65% total digestible nutrients), and fed cottonseed cakes at 0.3, 0.6, or 1.2% of body weight (2.2, 3.9, and 7.7 pounds per day, respectively). Hay was fed as large round bales that were weighed prior to feeding and replaced when approximately 10% of initial mass was remaining. Steer body weight at the end of the study was increased linearly with increasing level of supplementation, averaging 328, 336, and 345 for the 0.3, 0.6, and 1.2% of bodyweight supplementation rates, respec-

tively. Average daily gains also increased linearly with increased level of cottonseed cake supplementation, averaging 1.83, 2.07, and 2.31 pounds per day, respectively. Hay disappearance from the feeder was estimated to be 7.7, 9.9, and 6.8 pounds per day, respectively, resulting in total feed efficiencies of 5.4, 6.7, and 6.3 pounds of hay and supplement per pound of gain.

#### Impact

By-product feeds can help beef producers to moderate the effect of increased grain prices on production costs. More unique by-products will become available and in order to determine the handling and feeding characteristics of these feeds will require research to test each likely feeding program. Under the conditions of this study, cottonseed cake can be supplemented at rates up to 1.2% of bodyweight to steers fed medium-quality grass hay. Thus, cottonseed cake will fill a need for beef producers not only as a protein source, as it was used by past generations of producers, but also can be used as an energy source for growing calves.

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#### Funding

Division of Agriculture, University of Arkansas; Furst-McNess Company, Freeport, Ill.

### Assessment of the impact of genetic variation for internal parasite resistance in two Arkansas Angus herds

#### Issue

The physical environment in Arkansas is ideal for the support of internal parasites in cattle. It is estimated that the economic detriment in Arkansas cattle due to internal parasites ranges from \$25 to \$200/head. This includes losses in cattle performance and the cost of providing anthelmintic treatment. Overuse and continued utilization of some of the available anthelmintic products has led to development of resistance in parasites. It has also been reported that residues of anthelmintic chemicals have been found in food and the environment, indicating a need for methods of non-chemical parasite control. This might involve a compromise between performances in productivity traits and reduced chemical control. Research is needed to identify means of non-chemical control. The objective of this study was to determine genetic variation in innate parasite resistance/susceptibility and its relationship with economically important traits in beef cattle.

### Action

Purebred Angus calves (n = 273) at two locations over 3 years were used in the study. Calves were the progeny of 15 sires. At weaning (d 0), performance traits were determined and a fecal sample was obtained from each calf. Each calf received 10 mg/kg of fenbendazole to eliminate the residual worms. At d 21, a fecal sample was obtained to determine fecal egg count reduction. Additional data were obtained at d 66, d 111, d 156, and d 205.

### Impact

These data indicate that individual animal variation exists for calf resistance/susceptibility to internal parasites in this sample of Angus cattle. There were significant sire-of-calf effects for resistance/susceptibility, which suggest that artificial selection for resistance/susceptibility might be effective. Consequently, considering the annual Arkansas cow herd is about 990,000 cows and 750,000 calves and the cost of parasite treatment is \$20/head, a 10% increase in the number of resistant animals could result in a \$3,680,000 return to producers.

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## Coccidiosis vaccine imparts immunity to chicks

### Issue

Coccidiosis is a widespread disease of chickens caused by protozoan parasites of the genus *Eimeria* that is controlled by the inclusion of anticoccidial drugs in the feed. The most widely used compounds are a class of drugs known as the polyether ionophorous antibiotics. Although these drugs are used for disease control, concerns have been expressed regarding their use in poultry feeds. There is an urgent need, therefore, to develop alternative methods of control such as vaccination. Live vaccines are available for the control of coccidiosis, but in the USA, these are not widely used partly because little information has been published on their efficacy. In order to achieve maximum efficacy, vaccination usually requires the administration of small numbers of the transmission stage of the organism (oocyst) in the hatchery. There is almost no published information, however, on the development of the immune response in chicks vaccinated in this manner. The present experiments investigated the development of immunity in chicks vaccinated with small numbers of *E. maxima*, one of the most widespread species that infects the chicken.

### Action

Day-old chicks were immunized with a low dose (100 oocysts) of *E. maxima* and reared in floor-pens under conditions designed to simulate exposure to infection that might occur under commercial conditions. The development of the immune response was monitored by challenging them with larger doses at different times following vaccination. The results showed that, whether birds were reared on new or reused litter, excellent immunity developed by two weeks following vaccination. Clinical coccidiosis usually occurs in the field when birds are 3-5 weeks of age and thus, for this species, vaccination with a low dose of oocysts should provide adequate protection against coccidiosis.

### Impact

Previous studies on the acquisition of immunity involved administering large numbers of oocysts to birds aged six weeks or more. Newly hatched chicks have a less-developed immune system than older birds and therefore the present results are more relevant to the field situation. The results suggest that the vaccination of chicks with low doses of oocysts is a valid alternative to chemotherapy for the control of coccidiosis.

It has been estimated that globally coccidiosis costs \$2 billion/year. A better understanding of the immune response to infection helps development of improved methods for controlling this disease with consequent benefits to the poultry industry.

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### Funding

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## Tall fescue toxicosis mitigated by novel endophytes

### Issue

Tall fescue toxicosis costs U.S. livestock producers nearly \$1 billion annually in reduced weight, immune function, and reproduction. Recently, non-toxic, 'novel endophytes' (NE+) were incorporated into tall fescue and enhanced persistence of tall fescue without reducing cattle performance, but adoption of this technology has been slow. Our goal in this project is to determine the extent to which NE+ technology may mitigate the negative impacts of fescue toxicosis and thereby improve economic stability of cow/calf producers in the tall fescue region.

### Action

Both spring- and fall-calving cows grazed either toxic tall fescue (E+) or a combination of 25% NE+ and 75% E+. Additionally, spring-calving cows grazing 100% NE+ served as a positive control. Cows grazing pastures with 25% NE+ were moved to NE+ for 2 months in the spring and 1 month in the fall during periods when E+ appeared to exert the



greatest negative impact on cattle. We have completed the first year of a 3-yr study.

### Impact

Fall-calving cows were heavier and had higher body condition scores (BCS) at breeding, which could result in a greater number of those cows becoming pregnant during the breeding season. Moving fall-calving cows from E+ to NE+ pastures reduced hair scores as well, indicating some mitigation of tall fescue toxicosis. Rotating both spring- and fall-calving cows from E+ to NE+ increased cow body weight and BCS. Calves weaned from 100% NE+ pastures weighed 56 lb more at weaning than the mean of spring- and fall-born calves grazing E+, and fall-born calves weighed 51 lb more than spring-born calves at weaning. Using Arkansas state average calf prices (weight adjusted) on the actual date calves were weaned, the sale value for fall-born calves was \$72.55 greater than that of spring-born calves. Based on the first year of this study along with previous research at the same location, fall-calving cows appear to be able to contend with E+ better than spring-calving cows, resulting in heavier calves sold on a seasonally higher market and greater calf value. Converting E+ pastures to NE+ may not be necessary or economically viable if fall calving is an option for cattle producers.

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### Funding

USDA - National Research Initiatives Competitive Grants Program CSREES Award No. 2006-55618-17114 and Division of Agriculture, University of Arkansas

## Novel endophytes improve steer marketability

### Issue

Calves weaned from endophyte-infected tall fescue (E+) pastures often display long, rough, dead hair and are discounted at auction facilities because of this appearance. These calves also weigh less than calves from non-toxic pastures, thereby reducing their value substantially. Recently, non-toxic 'novel-endophytes' (NE+) were incorporated into tall fescue and enhanced persistence of tall fescue without reducing cattle performance, but long-term impacts throughout the life of calves weaned from NE+ pastures

have not been evaluated. Our goal in this project is to determine the extent NE+ technology may mitigate the post-weaning negative impacts of fescue toxicosis and thereby improve economic stability of cow/calf producers in the tall fescue region.

### Action

A total of 156 Gelbvieh x Angus crossbred spring-calving cows were allocated to pastures consisting predominantly of E+ or NE+ and cows began grazing during the fall of each year. Calves were born and remained on their assigned pastures until weaning in 2006 but were removed from NE+ in the summer of 2005 because of low forage availability from dry summer conditions. After weaning, calves grazed bermudagrass pastures followed by winter annuals. Steers were shipped to a commercial feedlot facility and heifers were retained and bred.

### Impact

Steers weaned from NE+ were heavier at weaning, at feedlot transport, and at the end of the feedlot period (88, 84, and 83 lb, respectively), and produced heavier hot carcasses (57 lb) than steers weaned from E+. Daily gains during the post-weaning and feedlot periods, and carcass quality and yield grades were not different between NE+ and E+. Heifers weaned from NE+ tended to be heavier at weaning (40 lb), but post-weaning gains were not different between forages. Therefore, producers retaining ownership of calves weaned from E+ pastures should not expect those calves to compensate for this reduced performance during later production stages on non-toxic feedstuffs, resulting in lighter weight calves at later production stages. Those purchasing calves weaned from E+ pastures should expect those calves to perform similarly to those weaned from non-toxic pastures and therefore should not discriminate against those calves by reducing the price per pound paid.

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### Funding

Division of Agriculture, University of Arkansas

## Use of crude glycerin from biodiesel production as a supplement for ruminants

### Issue

The demand and prices paid for fuel have provided an option to produce biodiesel from soybean oil in Arkansas. An alternative market for the oil may provide additional farm income, increase the supply of fuel, and add manufac-

turing businesses. Crude glycerin is the principal by-product from biodiesel production from fat or oil, such as soybean oil, and it contains glycerol, which has potential as a supplement for ruminant animals. Typically, 100 lbs of fat or oil react with 10 lbs of methanol in the presence of a catalyst, either sodium or potassium hydroxide. The excess catalyst and methanol are removed, but some methanol often remains in the crude-glycerin fraction. For each gallon of biodiesel, 0.76 lb of crude glycerin is produced and commonly contains 80 to 95% glycerol, 0 to 15% water, and 0 to 4% methanol. While it could be purified to pharmaceutical-grade glycerin, it is important to remove methanol before feeding crude glycerin. Glycerol is fermented rapidly and increases the proportion of propionic acid in the rumen, but dry matter intake of high-grain diets may be reduced. The effect of supplementing glycerol (and especially crude glycerin) on intake and digestibility by ruminants fed forages has not been tested.

#### **Action**

Crude glycerin (88.9% glycerol; 0.3% methanol) was obtained from FutureFuel Chemical, Batesville, Ark. Two levels (5 or 10%) of the supplement were mixed with medium-quality grass hay and compared to a control diet and to 10% molasses supplement. The four treatments were fed to 20 wether meat goats. Feed intake and digestibility of the diets were determined in the animal trial. Intake of hay and total dry matter did not differ among treatments. Digestibility of dry matter tended to be greater with 5% glycerin compared with the control and did not differ between 10% glycerin and molasses. Even if the glycerol were 100% digestible, the 10% improvement in total dry matter digestibility indicates an advantage to supplying the readily fermentable supplement. There is a potential for readily fermentable products to impact negatively on forage digestion, so a second experiment was designed to evaluate the impact on *in vitro* true digestibility and digestion kinetics of adding 0, 5, 10, and 20% crude glycerin to wheat, crabgrass, and bermudagrass—forages that varied widely in nutritive quality. *In vitro* digestibility of the forage and glycerol mixtures increased linearly for each forage. However, after accounting for the digestibility of the glycerol that was completely digested, glycerol had limited impact on digestion of crabgrass and wheat forage. Likewise, overall digestion kinetic measurements varied among forages but were not impacted by glycerol level. Therefore, it appears that glycerol may be included at levels up to 20% of the total diet without having negative impacts on digestibility; however, this level was not tested with animals.

#### **Impact**

Based on these results, supplementing meat goats at 5% of the total forage diet could prove beneficial to producers when feeding medium-quality hay. The energy supplement could potentially increase profitability by allowing producers to feed hay that is somewhat lower in quality. Nutritionists and managers should be cautioned that “crude glycerin” from the manufacture of biodiesel might contain methanol that is harmful to animals. It could also provide benefits to

the biodiesel industry as a use of the principal byproduct. While it would remain necessary to remove the methanol, crude glycerin could be sold without further purification. This conceivably reduces the costs associated with use of soybean oil for biodiesel and would benefit those farmers of Arkansas.

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#### **Funding**

Division of Agriculture, University of Arkansas Agricultural Experiment Station; FutureFuels, Inc. (Batesville, Ark.) provided the supplement and conducted some of the laboratory analyses.

## **Optimal nutrition programs increase breeder hen fertility, hatching egg production, and decrease feed costs per hatching egg**

#### **Issue**

A major limiting factor in the continuing development and growth of the poultry industry in Arkansas and the nation is the production of adequate hatching eggs and quality broiler chicks necessary to supply the industry. A key problem associated with the feeding and management of breeder strains producing ultra high-yield progeny is a significant reduction in fertile hatching-egg production, which has increased the feed costs per hatched chick. Dietary programs have been shown to have a direct effect on male fertility and hatching-egg production but limited work on female fertility has been conducted. Key factors that may affect female fertility during a production period may be weight, body composition, and age. Dietary programs that provide optimal egg production are utilized for breeder hens because there is a lack of information suggesting different requirements for fertility.

#### **Action**

Researchers at the University of Arkansas Division of Agriculture recently conducted a feeding study to determine the requirements for broiler breeders for crude protein and amino acids for maintenance and production. The breeder pullets were individually housed in temperature-controlled housing and fed synthetic diets to determine amino acid requirements for maintenance and fed semi-purified diets to determine production requirements. Breeder performance consisting of percent mortality, hatching-egg production, fertility, body weight gain, feed conversion, and egg weights were determined with these production studies. Breeders were shown to require diets containing significantly less crude protein for production and fertility than presently being fed by the industry. Breeders were shown to require 13% crude protein containing ideal amino acid levels providing approximately 20 g per day for optimal production

and fertility. The industry normally feeds a 16% breeder I diet and a 15.5% breeder II diet, providing as much as 26 g of protein per day. The University of Arkansas research shows that breeders fed 16% protein diets had an average of 82% fertile hatching eggs compared to 90.5% fertile hatching eggs with a 13% protein diet. The digestible essential amino-acid requirements determined for optimal breeder production were shown to be similar to previously suggested NRC(1994) requirements for arginine, methionine, phenylalanine, and isoleucine but the research showed a higher requirement for digestible lysine.

#### **Impact**

A 13% crude protein level in breeder I and breeder II diets would decrease the feed costs approximately \$4.00 per ton and 25 cents per breeder during the production period. The feed costs per dozen hatching eggs could be lowered by approximately 2 cents per dozen and the number of fertile hatching eggs increased eight percent from an average of 145 per breeder to 159 hatching eggs. The increased number of hatched chicks per breeder could increase by 10, increasing revenue by \$3.00 per breeder. The additional hatched chicks or hatching eggs are worth significantly more than just the increased monetary value of chicks. The continuing growth of the poultry industry in Arkansas and the U.S. will require that breeders increase the supply of quality chicks for grow-out to support the worldwide increasing demand for poultry meat. Breeders could be more selective in hatching eggs that are utilized for incubation and improve both chick quality and hatching percentage.

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#### **Funding**

Cobb-Vantress, Inc., Siloam Springs, Ark., and the Arkansas Agricultural Experiment Station, Division of Agriculture, University of Arkansas

### **The effect of different feed restriction programs on reproductive performance, efficiency, frame size, and uniformity in broiler breeder hens**

#### **Issue**

Modern broilers have incredible genetic potential for growth. The broiler breeders that produce these birds have the same potential for growth but are feed-restricted to prevent them from expressing it. This restriction is necessary to avoid the variety of problems that occur when broiler breeders are allowed to grow rapidly. Larger body weights and increased fat accumulation in broiler breeders have led to leg problems, early onset of sexual maturity, accelerated ovarian follicular development, and the incidence of multiple hierarchies and multiple ovulations. The ultimate result is poor reproductive function. Feed restriction helps to alleviate the effects of these problems. Broiler breeder managers prefer to utilize skip-a-day feeding programs due to the benefits asso-

ciated with uniformity. By feeding larger quantities of feed every second day, feed cleanup times are increased. This allows smaller, less aggressive birds access to the feed for a longer time. Skip-a-day feeding requires that birds deposit nutrients into body reserves after a meal and then remobilize those nutrients during the off-feed day. This process may be inefficient.

#### **Action**

Three studies were conducted at the University of Arkansas Division of Agriculture Poultry Research Farm comparing everyday and skip-a-day feeding from 4 weeks of age to 5% production. Several parameters were measured including efficiency of feed utilization and performance parameters. The studies aim to determine the effects of different feeding programs on growth, body composition, egg production, and various metabolic parameters. These included hepatic lipogenesis, lipogenic enzyme gene expression, and metabolic hormone profiles. The results of these studies will help broiler breeder producers to determine the impact of different feeding programs on feed cost and costs per hatched chick or hatching egg. The metabolic analyses will help to explain the reasons for differences in efficiency of growth, production, and body composition between the different feeding programs.

#### **Impact**

Understanding the economic impact of skip-a-day feeding will help producers to make more informed decisions about feeding strategies during rearing. The benefits of marginally improved uniformity associated with skip-a-day feeding may be outweighed by the significant improvements in efficiency due to everyday feeding. Studies showed repeatedly that everyday-fed birds utilized feed between 7 and 10% more efficiently from 0 to 25 weeks of age than skip-a-day-fed birds. Using average feed costs of \$191 per ton for starter, \$179 per ton for grower, and \$187 per ton for breeder diets, the feed savings by changing from skip-a-day to everyday feeding would be between 18 and 25 cents per bird. With approximately 75 million breeders in the United States, that would equate to a saving in feed costs between \$13.5 million to \$18.75 million. Apart from savings in feed costs, it was found that everyday-fed birds consistently produced four more hatching eggs than skip-a-day fed birds. Given a cost of \$1.60 per dozen hatching eggs, this equates to increased income of 53 cents per bird. With 75 million breeders nationally, the increased revenue from hatching eggs would equate to \$39.75 million. The total savings per breeder by using an everyday feeding system during the rearing period would be approximately 71 cents per breeder or \$53 million for the poultry industry on a national basis.

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## **Poultry manure as renewable energy resource**

### **Issue**

Fuel for space-heating is the single largest operating expense for most poultry growers. Costs for propane continue to escalate and threaten profitability of many operations. Poultry litter can be viewed as a renewable biomass energy resource that is generated on the farm. Broiler litter has about 60-70% of the energy content of wood or sawdust. Combustion of poultry litter is being considered as a way to utilize this resource in an environmentally friendly way to reduce consumption of fossil fuels, propane, and natural gas.

### **Action**

Biological engineers and poultry scientists in the University of Arkansas Division of Agriculture tested a broiler litter-fired furnace in a recent demonstration project. The prototype furnace was provided by an Arkansas company (Lynndale Systems of Harrison). The demonstration was conducted at the UA Applied Broiler Research Farm, near Savoy. The furnace was operated during the grow-out of two flocks of broilers from August 1, 2006 to November 24, 2006. A follow-up test in April 2007 provided performance data for an improved furnace prototype. A tractor front-end loader was used to move litter from an adjacent outdoor, covered stockpile to the fuel hopper, which automatically fed the furnace. The furnace sustained burns of 100% raw broiler litter. Combustion chamber temperatures were in the range from 600 to 1000°F. The improved furnace model delivered a peak heat output of 250,000 btu/h, consumed litter at a rate of 145 lb per hour, and exhibited a system efficiency of 30-33%. The manufacturer has planned further design improvements so that a future commercial furnace should save enough natural gas or propane to pay for the biomass energy system.

### **Impact**

The poultry industry has a need for multiple technologies to help respond to escalating fuel costs and continued environmental concerns. Litter-to-energy conversion is one idea that has great promise. The recent demonstration has shown that poultry manure can be combusted on-farm at rates over 1.5 tons per day to provide thermal energy needed for space-heating. Additional work is needed to test air emissions and find markets for litter ash. If successful, adoption of this technology would not only decrease litter application in sensitive watersheds, but it would displace expensive fossil fuels (propane and natural gas) with a renewable biomass energy source found right on the farm.

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Division of Agriculture, University of Arkansas; Arkansas Natural Resources Commission; Arkansas Department of Environmental Quality; U. S. Environmental Protection Agency

## **Impact of *E. coli* phytase, citric acid, and wheat middlings on growth of broiler chickens**

### **Issue**

One of the top issues in broiler nutrition is precision formulation, which deals with formulating diets that closely represent the needs of the broiler and with attempting to minimize the excretion of excess nutrients such as nitrogen (N) and phosphorus (P). Much of the P in broiler diets is bound to a molecule called phytate; a great deal of research has been conducted to evaluate the ability of various phytase enzymes to release phytate-bound P in broiler diets. Phytase is clearly an effective way to improve dietary P availability and therefore reduce P excretion, but citric acid (in poultry diets) and wheat middlings (in swine diets) have also been shown to have P-releasing activity. A comprehensive assessment of the interaction of phytase, citric acid, and wheat middlings in broilers' diets has not been conducted, therefore, the goal of this project was to investigate whether combinations of phytase, citric acid, and wheat middlings would result in improved P utilization in broilers' diets during the grower and finisher phases.

### **Action**

A study was conducted with broilers beginning at 21 days of age, at which time birds were allocated to one of fifteen dietary treatments each containing five replicate pens of twenty broilers. Treatments 1 through 4 consisted of a P-deficient diet with graded levels of supplemental P; diets 5 through 15 contained phytase, citric acid, and wheat middlings alone or in various combinations. Birds were fed the diets until 55 days of age, at which time growth performance and bone strength were determined. Weight gain and bone strength were improved by singular additions of phytase, citric acid, and wheat middlings; there also appeared to be a slight improvement in these parameters when combinations of these compounds were fed.

### **Impact**

These data illustrate that combinations of phytase, citric acid, and wheat middlings may be used with low-phosphorus diets throughout the entire grow-out period of broilers, potentially reducing dietary costs and phosphorus excretion



(an environmental benefit) without sacrificing performance or bone strength, which are economic and welfare issues. Further, as cost of ingredients like corn increases due to competition from the biofuels industry, incorporation of alternative ingredients like wheat middlings could be potentially important. Further research is needed to determine if feeding citric acid is economically feasible.

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## Novel approach to monitor cellular immune activities in poultry

#### Issue

The blood serves as an excellent window into immune response-related activities. However, for antigens present in tissues, the blood primarily serves to bring soluble and cellular immune components to the site of infection. Hence, the blood does not reflect efforts involved in the elimination of an infection in situ. Understanding these local antigen-immune interactions is critical for the development of effective vaccines and animal health management. However, repeated examination of events taking place in tissues is limited because tissue sampling tends to be highly invasive and often requires euthanization.

#### Action

To address the need for non-terminal, minimally invasive procedures to study immune response activities in tissues, Arkansas scientists have evaluated the use of growing feathers as a site to monitor pathogen-immune interactions in vivo. The living portion of the growing feather is a complex, vascularized, integumentary tissue consisting of the feather pulp encircled by the barb ridge and an outer sheath. It is a defined unit of tissue (approx. 3-mm diameter by 8-10 mm height) that is very accessible for injection of antigens or other test material. Injection and collection is easier and no more invasive than taking a blood sample. Time course studies examining immune activities induced in the feather pulp by injecting bacterial cell wall products, mitogens, or specific antigen have been highly successful. Moreover, activities observed parallel events described using more conventional tissue injection sites (i.e., wattle and wing web) with the advantage that for the feather these events could be observed in the same individual over time.

#### Impact

This novel procedure will yield significant new fundamental information regarding innate and adaptive immune activities and mechanisms of host-pathogen interactions taking place in vivo. This knowledge is critical for animal protection, disease treatment, and the accelerated development and design of effective vaccines and vaccine strategies, particularly for antigens where antibodies do not provide full protection. Knowledge gained from these studies will find direct application for animal health management and

breeding strategies in poultry and production animals in general.

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## Release and launch of Interactive Broiler Income Spreadsheet (IBIS)

#### Issue

Poultry production in Arkansas and the surrounding Ozark Plateau is undergoing fundamental change. Although technology and production economics are moving the industry toward fewer and larger production units, the predominance of operations with four or fewer poultry houses managed by part-time family farmers remains. Concerns about environmental quality, animal disease, energy costs, technological upgrades, and returns to investment are combining to add economic pressures to many producers' lists of concerns. Domestic poultry processors are also facing a wide array of pressures such as rising feed and energy costs, all of which may restrict their capacity to increase grower pay. There is growing concern that some segments of the industry may move off-shore to reduce costs and improve competitiveness. In addition, the consolidation of the industry has left many rural communities with few sustainable or viable options for maintaining their farming heritage. Other communities have experienced rapid expansion of the industry with associated social pressures.

#### Action

The poultry industry has experienced unprecedented efficiencies since 1960 in large part due to vertical integration facilitated by production contracts between growers and integrators. As growers seek information about contract production, they need to be well informed about all aspects of the process, especially net income and cash flow expectations resulting from more accurate expense and revenue estimates. The Interactive Broiler Income Spreadsheet (IBIS) is developed to enable current and prospective poultry producers (breeder hen, pullet and broiler grow-out) to better estimate income. IBIS, an interactive and unbiased Flash-based™ tool to assist in decision-making regarding broiler production profitability, is capable of using either actual grower expense and revenue information or grower-panel default data to assess income under various grower-specified production, expense, and price scenarios. Poultry integrator grower service personnel, lenders, and Cooperative Extension professionals may utilize IBIS to assist growers in operational planning and risk-tolerance identification in varying economic situations. Growers may also gauge effects of capital improvements, equipment upgrades, chick placements, and time between flocks on income. IBIS is updated periodically through collection of additional data and revision of procedures based upon field testing and is available on the University of Arkansas Web site.

### **Impact**

The direct impact of the poultry industry in Arkansas is substantial. In terms of labor income, poultry production and processing accounted for \$1.5 B in 2003; 44,960 jobs were attributable to these activities and \$2.7 B in value-added was contributed to the state's economy by them. There are approximately 6,000 poultry farms in Arkansas operating around 15,000 houses. Planning and decision-making guides are particularly important now as propane approaches \$2 per gallon and other energy costs escalate at alarming rates.

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## **Genetic analysis of selected traits in swine**

### **Issue**

Selection based on performance data may have important effects on other traits not included in the selection criteria due to genetic correlations among the traits of interest.

### **Action**

Work continues on estimation of genetic correlations between performance test traits and subsequent reproductive performance in Landrace, Yorkshire, Duroc, and Hampshire breeds of swine. Relationships between performance test traits and subsequent reproductive performance in first parity females in these breeds were examined.

### **Impact**

Knowledge of the impact that selection for one trait (or group of traits) will have on other traits (or group of traits) is needed by producers when developing selection programs.

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## **Comparison of bloat potential between soft-red and hard-red winter wheat forages**

### **Issue**

Millions of stocker cattle graze winter wheat pastures throughout the Southern Plains of the United States. These cattle can have high rates of gains while grazing winter wheat, but wheat-pasture bloat can be a major problem. On average, annual death losses of 2% are caused by wheat-pasture bloat; this can be as high as 20% with serious outbreaks.

Wheat-pasture bloat is a type of frothy or foamy bloat where gases produced by microbial fermentation become trapped in a polysaccharide slime layer in the rumen and cannot be eructated. If untreated, rumen pressure builds and interferes with lung respiration, causing suffocation and death. The majority of the wheat forage in the Southern Plains is a hard-red winter wheat, yet in Arkansas most wheat grown is soft-red. Anecdotally, there have been few reports of bloat in cattle grazing wheat in Arkansas. There has been no published research into possible differences between wheat types in bloat-causing potential. Determining if a wheat type is more or less apt to cause bloat may give producers a chance to use lower bloat-potential wheat forage. The objective of this study was to determine if soft-red and hard-red winter wheat had different bloat-causing potentials.

### **Action**

Fifty-four heifers, 8 of them ruminally cannulated, grazed pastures of either hard-red or soft-red winter wheat to evaluate the effect of wheat type on bloat potential. In Experiment 1, cattle grazed in November and December 2006. In Experiment 2, cattle were held in a small pen without feed for 20 hours and then grazed from Dec. 19 to 20, 2006 and from Jan. 19 to 20, 2007. In both experiments, bloat was visually scored 2 times a day, and rumen samples were taken 3 times a day from the cannulated heifers and evaluated for pH, foam production and strength, and fluid consistency. Forage availability was not different between hard-red and soft-red winter wheat. Bloat incidence was low (some distension observed for 2.1% of the observation times) for the non-cannulated cattle, with no difference between hard-red and soft-red winter wheat. The cannulated heifers grazing soft red had a greater percentage of observed bloat (21.8 vs. 5.6%) than heifers grazing hard-red winter wheat. Rumen fluid from heifers on soft red was more viscous than fluid from heifers on hard red. Foam production was similar between wheat types at the first morning sampling time, but soft red had greater foam strength at noon and later in the day. In Experiment 2, no bloat was observed. Also, no differences between wheat types were observed for any of the rumen foam measures.

### **Impact**

Contrary to what was expected, it appears that soft-red winter wheat had a greater bloat potential than hard-red winter wheat based on results from the cannulated heifers. However, no differences between the wheat types were observed in the frequency of bloat in the non-cannulated cattle. Producers should remain diligent in watching for signs of bloat in cattle grazing wheat; the reasons for the reduced incidences of bloat in Arkansas remain to be discovered.

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#### **Funding**

Division of Agriculture, University of Arkansas

### **Cell culture approach for vaccine development of poultry viruses**

#### **Issue**

Avian viral diseases, such as avian influenza, Newcastle disease, pneumovirus, Marek's disease, or laryngotracheitis, cause economic losses in poultry industries by decreasing productivity. Vaccines of either killed or live, attenuated viruses have been used efficiently to protect poultry flocks. However, development of more rapidly produced and more effective vaccine is required to minimize the loss in poultry production. Genetically modified, recombinant vaccine development is a highly efficient approach to protect from infectious viral pathogens. In addition, continuously growing homologous avian cell lines can support the stable substrates for recombinant vaccine production. Currently, there is a heavy reliance upon avian eggs and primary avian cell cultures as substrates for the production of vaccines. Cultured primary cells can be highly variable and can be potentially contaminated with endogenous viruses. In addition, the source of primary cultures can be limited due to the availability of stocks and expensive due to the necessity of maintaining stocks in a specific pathogen-free state. Immortal avian cell lines should serve as a better alternative for the production of poultry vaccine products.

#### **Action**

Arkansas scientists are currently conducting studies on the development of immortal chicken-cell lines that can efficiently produce avian infectious laryngotracheitis virus (ILTV). To find suitable homologous cellular substrates, numerous chicken primary cells were isolated from lung, trachea, liver, heart, muscle, intestine, kidney, and bursal tissue. Primary cells derived from kidney, liver, and lung generated positive cytopathic effects and produced moderate ILTV titers. Investigations continue into modulations of cellular factors in the candidate primary cells by molecular techniques that can generate a continuously growing cell line.

#### **Impact**

A virus-free immortalized chicken-cell substrate, which can efficiently propagate ILTV, would be suitable for use in the manufacture of animal vaccine products. A certifiable and well characterized, continuously growing (immortal) cell line is expected to become of primary importance to industry to reduce or eliminate the need for egg or primary animal tissues and subsequent establishment of cell cultures. This should, in turn, result in improved quality control. The implementation of a continuous cell line derived from primary animal tissues should enable manufacturers of biological vaccines to assure better control over production processes, increase product safety and consistency, and ultimately

reduce costs.

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U.S. Poultry and Egg Association; Division of Agriculture, University of Arkansas Agricultural Experiment Station; Animal Health Funds

### **Early-growth cool-season forage can reduce pregnancy rates**

#### **Issue**

The early growth of cool-season forages is typically very high in protein. Research in dairy cattle has shown that forages which are excessively high in nitrogen (crude protein) content can lead to high levels of urea in the blood of cows. The high blood urea nitrogen (BUN) has been shown to decrease pregnancy rates in cows. There is therefore the potential for early-growth cool-season forages to contribute to reduced pregnancy rates in beef cattle. Additional energy added to the diet of cows consuming high-protein forages may improve the utilization of nitrogen and reduce BUN.

#### **Action**

A series of trials is being conducted in order to evaluate the effects of adding energy supplements to the diets of heifers grazing ryegrass pastures in the early spring. Heifers receive either no supplement, 30 days of supplement at 60 days prior to breeding, or 30 days of supplement starting at 30 days prior to calving.

#### **Impact**

Reproductive efficiency is one of the most important economic factors involved in beef cattle production. Methods to improve reproductive efficiency by improving the utilization of nitrogen of cool-season forages would be of great economic benefit to Arkansas beef producers. We have found that serum urea nitrogen is elevated to concentrations that could be detrimental in the very early parts of the spring growing season, in cattle grazing the early growth of ryegrass, but that these levels declined before animals were exposed to AI and did not affect conception rates of AI. Complete data from this study are being summarized.

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#### **Funding**

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### **Cell and molecular biology research into bovine reproduction**

#### **Issue**

The genome has been sequenced for several species,

including the bovine, and it is possible to locate and identify specific genes. Once genes are identified and their sequences determined, the next step in understanding how specific genes function is to determine specifically how genes are turned on and turned off.

#### **Action**

We have succeeded in isolating the promoter (control) region of the bovine beta follicle-stimulating hormone gene from bovine genomic DNA. We have created truncated segments of the control region and inserted the sequence into a plasmid vector that can be transfected into mammalian cells in order to study its functions. We will use these truncated segments of the FSH promoter to determine specifically what intracellular and extracellular factors enhance or reduce the secretion of bovine FSH.

#### **Impact**

FSH is one of the two gonadotropins that are essential for successful reproduction in all animals. An understanding of the control of FSH production at the level of the gene will enable a better understanding of the control of reproductive function in animals and provide the potential for the development of tools or methods to control or enhance reproduction in domestic animals. In addition, a basic understanding of how gene-promoter sequences function in the control of gene expression may have application to the control of other genes and in the production of transgenic animals.

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## **Bovine respiratory disease explored through genetic markers**

#### **Issue**

Ascites is a genetically linked condition in broilers that results in pulmonary hypertension and in the accumulation of fluid in the thoracic cavity. The condition is prevalent in lines of broilers that have been heavily selected for growth and performance and contributes significantly to production losses in the broiler industry.

#### **Action**

We initiated studies in ascites-resistant and ascites-susceptible broiler lines to investigate the occurrence of gene polymorphisms in the promoter regions of genes that are related to inflammation and blood flow in the pulmonary system of broilers. These studies were conducted to find genetic markers that might be useful in the selection of birds that are resistant to ascites.

#### **Impact**

We have found two polymorphisms in one gene that occur with much higher frequencies in resistant broiler lines than in the susceptible line, and three polymorphisms in another gene that occur at much higher frequencies in the

susceptible line than in the resistant line. We are collecting additional data to verify these results. These markers could be very important in developing selection tools to help select broiler lines that are naturally resistant to ascites.

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## **Bovine respiratory disease and natural immunity in beef calves**

#### **Issue**

Bovine respiratory disease (BRD) is widely regarded as the most costly disease to affect the beef cattle industry. The disease affects primarily stocker and feedlot calves and causes mortality and high morbidity. Treatment requires the extensive use of antibiotics and animals frequently perform poorly even if they recover after treatment.

#### **Action**

We have begun studies of several genes involved in the natural immune response of beef calves in order to find genetic markers that can be used to determine if calves are more or less resistant to BRD.

#### **Impact**

The ability to identify animals that are naturally resistant to BRD will potentially enable the selection of animal lines more resistant to BRD. In addition, from an animal management standpoint, the ability to identify susceptible and resistant animals would allow the more effective and judicious use of antibiotics and other treatment therapies.

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#### **Funding**

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## **Cattle parasite test fingerprints helminth DNA**

#### **Issue**

The correct identification of the organisms that infect cattle and an accurate count of those that resist treatment are important steps in the evaluation of the effectiveness of internal parasite control programs in cattle. However, the accurate identification of the larval forms of parasites that infect cattle is difficult and time-consuming due to the very small morphological differences in the larvae of different species when examined under the microscope.

#### **Action**

We are using a technique developed by USDA scientists to identify the larval stages of major cattle parasites through the extraction of parasite DNA and the identification of sequences that are unique to specific organisms. We intend



to extend this technique to enable determination of the relative amounts of DNA from each organism so that this test can be used as a highly accurate and efficient method for the study of parasite resistance and the effectiveness of various anthelmintic treatments.

#### Impact

The availability of a technique to accurately and rapidly determine the quantity and type of helminths present in cattle would be beneficial in the development of new anthelmintic drugs as well as in the accurate identification of resistant organisms that may pose future problems for producers.

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## Understanding stress responses in poultry: From the whole organism down to the molecular level

#### Issue

The textbook explanation of the stress response in man and animals is that a single type of nerve cell in the ventral brain region releases a peptide (neurohormone) called CRH that stimulates the pituitary (master endocrine gland of the body) to release a second hormone (ACTH) into the blood stream that activates the adrenal gland to produce a stress hormone corticosterone (CORT). A problem with this simple pathway is that it cannot continue to release CORT under conditions of *chronic* stress in that the stress hormone will feed back negatively to shut down the activity of its primary nerve cell, the CRH neuron. How then can an animal continue to produce levels of CORT required to maintain homeostasis of body processes during periods of sustained stress? Our goal was to provide evidence that similar to man, birds have more than one type of neuron responsible for regulating the stress response and that the bird has a neuroendocrine system as sophisticated as that of man to regulate well its body levels of CORT in acute as well as chronic periods of stress.

#### Action

To address the issue of providing a mechanism explaining how birds can regulate and sustain high levels of CORT during periods of stress, we designed experiments involving birds and cell cultures. First, we showed that in the chicken, similar to mammals, there are two distinct types of neurons: CRH and AVT neurons responsible for stimulating the release of CORT into the blood. Importantly, when both CRH and AVT are injected simultaneously in chicks, the resulting release of CORT exceeds the sum of effects produced by CRH and AVT injected alone, causing a so-called synergistic effect.

We wished to provide evidence showing how two dis-

tinct neurohormones (CRH and AVT) could release CORT and showed that in the pituitary, there were two distinct receptors—one for CRH and one for AVT—located on the same pituitary cell type. It is well known that receptors found on cells respond to compounds binding to them by producing intracellular second messengers. We therefore measured the quantity of the second messenger (cAMP) produced when CRH, AVT, and CRH+AVT were added to the cells that contained both receptors. Interestingly, a synergistic release of cAMP occurred when both CRH and AVT were added together, compared to the cells' response from the addition of CRH or AVT alone.

To obtain a cellular mechanism explaining that synergistic response, an experiment was completed whereby cells were transfected with a vector that fused each receptor protein into their cell membrane. An assay was then developed to verify that a signal transduction pathway was functional in the specially modified cells. Thereafter, a special imaging technique called quantitative fluorescence resonance energy transfer (FRET) analysis was used to determine if the two receptor types interacted when compounds bound to each receptor. Indeed, using a confocal microscope, a molecular complex, called a heterodimer, was formed that was verified as having its components move closer together forming a complex that could explain the increased release of the second messenger, cAMP, when both receptor types were occupied by substrates.

#### Impact

The major significance of our findings is that a biological response—specifically greater release of a stress hormone over time—can be explained at the cellular level in birds. It means that another physiological response of the bird is quite similar to the stress response of mammals, demonstrating that the chicken is an excellent biomedical model for investigating the stress response as it relates to humans. The main, technical reasons are as follows. The major neurohormone, CRH, involved in the stress response, has the identical amino acid sequence (41 amino acids) as that found for humans. The second neurohormone, AVT in the bird, is only different from the human neurohormone, vasopressin, by one amino acid. It has been shown in mammals this past year (2007), similar to our experiments in chickens, that heterodimers are formed within the cell membrane when the two distinct receptors are occupied (refer to Mikhailova et al. publication below). Similar to results obtained in rats, central administration of CRH is more efficacious in releasing CORT than AVT (refer to Madison et al. publication below).

Therefore, these data strengthen the position of the chicken as a useful model to determine further at the cellular and intra-cellular levels the process by which stress responses are regulated when they shift from an acute incident to a chronic state. Clearly this fundamental system that has evolved in vertebrates to cope with stress has been highly conserved in birds and mammals and thereby provides strong evidence that research directed to this biological system in birds will have direct application to mammals, including man.

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## Portable impedance biosensor for in-field detection of avian influenza (H5N1)

### Issue

Avian influenza (AI) virus (H5N1) was discovered in the late 1990s, and it has been reported by WHO to be in more than 46 countries for animal cases and in 14 countries for human cases with 349 people infected and 216 deaths since 2003. In the U.S., a recent outbreak of low-pathogenic AI in 2001 and 2002 resulted in the depopulation of over 4.5 million chickens and turkeys that cost the poultry industry approximately \$125 million in losses. The World Bank estimates that more than 140 million birds have died or been destroyed due to AI (H5N1) and losses to the poultry industry are in excess of \$10 billion worldwide. A key in controlling the spread of AI is to rapidly detect the disease, eradicate infected animals, and quarantine and vaccinate uncultured animals. The technology for detection of AI (H5N1) is mature, but many tests are complex while some are liable to error, and some can be performed safely only in BSL3 facilities. A simple, rapid, robust, and reliable AI test, suitable for use in the field, is urgently needed.

### Action

A portable biosensor has been developed for sensitive and specific in-field detection of AI virus (H5N1) in poultry swab samples. Magnetic nanobeads are coated with specific antibodies to the target virus and are used in the sampler to separate and concentrate the target virus from a poultry swab sample. Red blood cells, as biolabels, are mixed with the captured target virus to form the bio-nanobead-virus-red blood cell complex. A microfluidic biochip is designed and fabricated as a flow-through device to deliver the complex to an embedded, interdigitated-array microelectrode for impedance measurement. The change in impedance of the bionanobead-virus-red blood cell complex is correlated to the concentration of AI virus (H5N1) in the original swab sample. Results showed a positive signal was clearly obtained when the concentration of AI virus (H5N1) in cloacal swabs was equal to or more than 100 EID<sub>50</sub>/mL. At 10 kHz fre-

quency, the impedance of AI virus (H5N1) significantly increased as compared to either no viruses or only Newcastle and infectious bronchitis viruses. A U.S. patent has been filed. A research prototype of this biosensor has been designed and fabricated and is being evaluated with viable AI (H5N1) in a BSL-3 lab and field tests.

### Impact

Since currently there is no in-field AI test instrument available, this biosensor would provide the poultry industry with a very needed technology for rapid, sensitive, and specific screening of AI (H5N1) in poultry. This will help the poultry industry be better prepared for AI (H5N1), ensure poultry product safety and security, and minimize testing cost.

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### Funding

USDA/NRI; Arkansas Biosciences Institute; U of A Center of Excellence for Poultry Science; Division of Agriculture, University of Arkansas

## Poultry Science Department certifies Tyson product developers as Certified Culinary Scientists through specialized culinary classes

### Issue

The poultry/meat industry is a mature industry that is part commodity market and part value-added with higher profit margins. Individual company growth in profits can be expected from increased percentage of value-added and food-service markets.

### Action

Early in 2005, Dr. John Marcy, Poultry Processing Specialist in the Poultry Science Department and local chef, Suzie Stephens, approached Tyson Foods Research and Development to offer hands-on culinary classes at the University of Arkansas to enable their product developers to achieve certificates titled "Certified Culinary Scientist." This recognition is from the Research Chefs Association, a group dedicated to the blending of culinary arts and food technology (Culinology). This experience is meant to enable the product developer to work comfortably with the chefs employed by Tyson Foods and also with the chefs employed by the customers of Tyson Foods.

Tyson Foods established a goal of getting 60 of their product developers certified as "Certified Culinary Scientists" in 2005. The Tyson Discovery Center opened in January 2007 and the first Tyson associate became certified as a Certified Culinary Scientist that same week. Classes

continued in 2007 and at the end of 2007, 23 Tyson associates had completed the required 120 hours of hands-on culinary training and were able to proceed toward the certification process. Seven associates were certified in 2007.

### Impact

All of the work and investment of the company to develop a culture of chefs and food scientists working together has created an effective product development concept that has been deemed worthy of recognition. Tyson received the Innovator of the Year award from *Poultry Magazine* in 2007 based on their dedication to uniting culinary arts with food science through education and certification by the Research Chefs Association. Senior Vice President of Research and Development, Hal Carper, stated that he considered it as a joint award shared with John Marcy and the University.

Conducting these classes at the University of Arkansas is what makes the program possible for Tyson as well as other Arkansas companies. After the program started with Tyson, Chef Stephens and I proceeded to develop new courses for Simmons Foods in Siloam Springs and now seven of their product developers have also completed the 120 hours of culinary arts training.

Because of those additional courses developed in 2007, the Research Chefs Association has agreed to partner with the University of Arkansas to offer culinary arts to food scientists across their large membership. Three weeks of classes will be offered in 2008.

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### Funding

Individual companies paid registration fees to cover expenses for their employees.

## Influence of complexed minerals on sow reproductive performance, longevity, and associated lameness challenges

### Issue

It is clear that reproductive performance in swine breeding herds is below the accepted potential for sows/gilts managed under commercial conditions. Research from Australia indicated that an increase in both reproductive and structural problems was causing higher culling rates. These researchers noted that a parity-related reduction in sow performance was occurring much earlier, at parity 4-5, than has been traditionally assumed. A stable commercial unit at QAF Meats in Corowa, NWS, Australia, was surveyed over a 12-month period. Reproductive failure was mostly the result of post-weaning anestrus (26%) and a failure to conceive (20%). There was also a high percentage of sows that

became pregnant and failed to continue pregnancy (36%). The number of sows/gilts culled for structural/skeletal problems was 14.9%. Lameness challenges in large confinement dairy herd systems have been more extensively investigated than those associated with large confinement swine systems although lameness problems and associated foot lesions seem to be a major problem in the sow herd and account for a large percent of the replacement-rate problem experienced in confinement swine production systems. The impacts of mineral source on mineral status, skeletal/locomotor problems, longevity, and reproductive performance have not been sufficiently addressed in sow herds.

### Action

The University of Arkansas has initiated a series of studies to determine the extent of reproductive and structural problems in the University sow herd and to evaluate the effect of complexed minerals on the incidence of specific locomotor characteristics and sow reproductive performance. The sow research herd was evaluated for claw lesions over 3 successive breeding cycles. The sow herd is on a batch-farrowing system (4 groups/breed cycle) and one group farrows every 5 wk. Sows were housed in conventional gestation crates and fed approximately 5 lb of a standard gestation diet daily, with ad libitum access to water. At 110 days of gestation, sows were moved into the farrowing barn and housed in a conventional farrowing crate with a cast-iron floor for the sow and a plastic floor for the piglets. Sows ended lactation between 19 and 21 days post-farrowing. Following weaning, the sows were given 7 d to be rebred. The week following breeding, each sow was evaluated for lesions on each of her 8 claws in a modified calf table where she was oriented on her side and her limbs were restrained with nylon ropes. The same technician evaluated each sow over the course of the entire study. A total of 10 different types of lesions were evaluated. Soft-tissue lesions of the heel and sole evaluated were heel erosion, Fischer's cracks, and excessive soft-tissue growth. Two lesions associated with the white line of the claw were evaluated. There were axial (inner, medial) white line cracks and abaxial (outer, lateral) white line cracks. The remaining lesions were associated with the wall of the claw and were found on lateral or medial sections of the wall of the claw. Over a period of 18 months, 2086 different lesions were noted within the University of Arkansas sow research herd, which included 204 sows that were measured on average 2.5 times throughout the study. During the study, greater than 95% of the 204 sows evaluated had at least one of the noted lesions. Of the 10 lesions evaluated, heel erosions occurred most frequently in the herd (74.0% of the sows), followed by abaxial (outer) white line cracks (40.0%), Fischer's Cracks (34.5%), vertical cracks (25.5%), hemorrhages (20.0%), axial (inner) white line cracks (14.5%), and the rest of the lesions occurred in less than 10% of the sows. For all types of lesions, the rear outer claws had the greatest frequencies of lesions noted. The front outer claws were second in lesion frequency. Hemorrhages and abscesses tended to occur on the front claws rather than the rear claws, while soft-tissue lesions appeared most often on the rear claws.

### Impact

There is little research published in the area of claw lesions in swine. Within the University of Arkansas sow research herd, lesions were observed at least one time in nearly all of the sows during the study. The majority of the lesions were found on the outer claws and primarily on the rear feet. These preliminary data will be used to establish procedures that will allow the evaluation of the effects of complex minerals on the incidence and severity of claw lesions and reproductive performance in swine.

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### Funding

Private industry; Division of Agriculture, University of Arkansas

## On-line sorting of beef carcasses to guarantee tender beef

### Issue

Toughness is the most common qualitative problem in the beef industry. Tenderness is an important attribute of beef acceptance by consumers and as such an important component of meat quality. It is common knowledge that a significant proportion of meat from carcasses of USDA select and the lower one-third of USDA choice is considered tough by consumers. Because this range of USDA grades represents the majority of the carcasses processed in the United States, the beef-eating experience can vary greatly for consumers. On-line sorting devices capable of distinguishing carcasses yielding tender or tough meat would be of great significance for the beef industry. In particular, the successful implementation of such a system could lead to the creation of guaranteed tender beef brands.

### Action

A device (UA Tendertek) consisting of a portable material testing machine and a series of small and minimally invasive blunt blades was developed. The method consists of measuring the resistance to shear for measurement made in the exposed surface of the *Longissimus Dorsi* at the 12th rib split made for the purpose of grading. The device was tested in two beef plants on a set of 90 carcasses of USDA grades Select and Choice. Strip loins were harvested and tenderness evaluation performed at 7 and 17 days post mortem. Correlations between carcass UA Tendertek results and cooked steak tenderness were investigated.

### Impact

UA Tendertek measurements were found to be significantly correlated to cooked meat instrumental tenderness measurements and consumer liking for meat aged for 7 and 17 days. Of the carcasses predicted to be tender, 91% were found to be tender 7 days post mortem while 100% of these carcasses were found to be tender after 17 days of aging. Testing with consumers showed a significant improvement in liking for UA Tendertek tender beef.

This invention is of very high significance to the meat

industry. Taking the example of the beef industry, the United States alone will process 27 billion lb of beef. Of that, approximately 40% will be of USDA select and lower (10.8 billion lb). We estimate that approximately 30% of that amount (based on preliminary experiments) constitutes tender meat that could be marketed as "guaranteed tender." Consumers have been shown to be willing to pay a premium of \$0.50 per lb for guaranteed tender beef products. This means that the beef industry could realize additional profits in the amount of \$1.6 billion annually.

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## Impact of early deboning and portioning on tenderness of vertically portioned broiler breast fillets

### Issue

Uniformity of boneless breast fillets is a highly desired aspect in the food service industry. In order to accommodate the demand for uniform product, poultry producers portion breast fillets to achieve the perfect size and shape. Tenderness is also an important consumer issue and early deboning can often result in decreased tenderness. Portioning fillets early postmortem may also negatively impact meat tenderness. The purpose of this study was to determine the effect of time of portioning and genetic strain on tenderness of vertically portioned breast fillets.

### Action

One hundred-twenty six-week-old broilers from two commercial high-yielding broiler strains were processed via an in-line system and then chilled with a two-stage method in 3 replications. Broiler carcasses were deboned at 2h or 4h postmortem (PM). Boneless breast fillets were vertically portioned at time of deboning (2h or 4h PM) or at 24h PM (i.e., after aging of deboned breast fillet) using a heart-shaped standard template removing cranial and caudal fractions. All fillets were cooked 48h PM to an internal temperature of 76°C and sheared using the MORS method, recording total energy (TE).

The results of this study suggest portioning with vertical cuts early postmortem can decrease meat tenderness to a greater degree than deboning alone. Processing procedures (e.g., deboning and portioning) had a greater impact on tenderness than the effect of commercial strain.

### Impact

Early deboning and vertically portioning early postmortem have additive effects on meat tenderness where both cause a decrease in meat tenderness (i.e., increase in toughness). Vertical portioning, early postmortem, results in a further toughening effect after early deboning. This can result in a significant quality loss, which could negatively impact consumer acceptability and consumer purchasing



choices. Furthermore, producing tough products has the potential for a company to lose major customers.

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### Optimizing NaCl marinade concentrations to improve meat tenderness, flavor, and juiciness of early deboned broiler breast fillets

#### Issue

Previous studies show that marination of broiler breast meat improves meat quality attributes and yield. Marinades typically contain salt and phosphates; however, due to increased health awareness, trends for lower salt content have increased. The purpose of this study was to evaluate the effect of various salt concentrations on early-deboned boneless breast fillet tenderness and juiciness.

#### Action

One hundred fifty broilers, six-weeks of age, were processed via automated line, chilled in a two-stage process, and deboned at 2 h postmortem. Test fillets were vacuum tumbled for 30 min with a 15% marinade containing phosphate (0.45%) and salt (NaCl) concentrations of 0.33, 0.50, 0.75, or 1.0%. Control samples were neither tumbled nor marinated. Cooked fillets were subjected to instrumental analysis using the MORS method (total energy; TE) and consumer sensory analysis using hedonic and just-about-right scales to assess texture, intensity of tenderness, saltiness, and juiciness. Tenderness of breast fillets was highly correlated to salt concentration; TE decreased with increasing salt concentration, indicating improved tenderness due to marination. Salt concentrations of 0.5% or more resulted in a significant decrease in TE compared to control. According to the consumer panel, a minimum of 0.33% salt was needed to improve texture/tenderness; values further improved as salt concentration increased. Less than 16% of consumers considered marinated fillets as “too tough” compared to 49% who considered the control fillets “too tough.” The attribute, “saltiness,” increased as the levels of salt concentration increased, but even at the highest level (1%), only 14% of consumers considered fillets “too salty.” When compared to the control, marinating with any level of salt improved juiciness. Yet, marinating with less than 1% salt, many consumers (31-41%) considered the cooked products “too dry.”

#### Impact

Marination of early deboned breast fillets, even with low salt concentrations, can improve tenderness of early deboned meat to acceptable levels, which results in an improvement in quality. This improvement in quality of early deboned meat will help prevent loss of customers (i.e., prevention of losing hundreds of thousands of dollars through loss of sales). Marinating with lower levels (<0.5%)

of salt may lead to a less juicy product compared to higher levels of salt though end users may use additional ingredients in meal preparation which may lead to improved juiciness. Using lower levels of salt can keep ingredient costs low. Furthermore, using lower sodium levels may prevent increased risk for health problems associated with sodium intake.

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#### Funding

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### Influence of reproductive tract score on pregnancy rate in beef heifers

#### Issue

The selection and development of replacement heifers is a major economic burden to the beef cattle industry. Management of replacement heifers is a costly and intensive process. Heifers that breed early during their first breeding season calve earlier and wean heavier calves than those that conceive later in the breeding season. Furthermore, heifers that conceive earlier in the breeding season tend to consecutively breed early throughout the rest of their productive lives. Pregnancy rates were higher for heifers that had already begun cycling compared to heifers that had only had one estrus cycle when exposed to fertile bulls. Therefore, it is important to utilize early determination of the heifers that will likely be sound, productive replacements versus the heifers that will not be sound replacements.

#### Action

A study was conducted by the University of Arkansas Department of Animal Science during 2006 and 2007. This study was conducted to determine if the use of reproductive tract scoring influences pregnancy status in replacement heifers (n = 104). Reproductive tract scoring was accomplished with transrectal ultrasonography. At the time of scoring and breeding, heifers were approximately 65% of their mature body weight (BW = 764 lb). All heifers were exposed to fertile bulls and bred by natural service over a 63-day period. After breeding, pregnancy status was determined with the use of transrectal ultrasonography. This study identified a difference between the pregnancy rates of replacement heifers with a low reproductive tract score and those with a higher reproductive tract scores (P < 0.05).

#### Impact

Development of replacement heifers can be one of the most costly expenses to a beef cattle producer. Decisions to cull poor-performing animals early could likely decrease losses associated with their further management. Utilizing reproductive tract scoring can be a useful tool for assessing pregnancy outcome. This effective procedure could be utilized by cattlemen in Arkansas to make culling decisions

before the breeding season begins. Therefore, heifers with poor reproductive potential could be eliminated from the herd, increasing overall profitability of the operation.

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**Cooperators**

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**Funding**

Fort Dodge Animal Health Overland Park, Kansas; Division of Agriculture, University of Arkansas

## Gene mapping addresses broiler fertility deficits

**Issue**

Male and female fertility remains an important issue in the broiler breeder industry. Selection for meat production has always been negatively associated with fertility, reducing flock performance and production of breeding stock.

**Action**

We have been mapping genes that affect sperm viability and mobility in broilers. We have identified 13 chromosomal regions affecting sperm degeneration or sperm mobility. Those regions are being intensively studied to understand the contributions of each to male fertility and to determine the underlying genetic basis for poor male fertility. In addition, we are using a candidate gene approach to identify genes affecting female egg production.

**Impact**

Our research will lead to genetic tests that will predict important aspects of male and female fertility. These tests will allow the broiler breeder industry to select for these traits and improve overall flock fecundity and performance.

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**Funding**

Arkansas Biosciences Institute; Cobb-Vantress, Inc.; Division of Agriculture, University of Arkansas

## Research targets genetic markers for mastitis-resistant cows

**Issue**

Mastitis is the most prevalent disease affecting dairy cattle, costing an estimated 2 billion dollars annually in the U.S. Selection for increased milk production has also resulted in increased incidence of mastitis. Over time, mastitis-causing bacteria have developed resistance to antibiotics, making treatment less effective. Organic dairy producers have no option for antibiotic mastitis treatment, regardless of effec-

tiveness. There is genetic variability in susceptibility to mastitis within and among breeds of dairy cattle, so mastitis susceptibility might be reduced by identifying differences among cows in their expression of genes related to mastitis resistance or susceptibility.

**Action**

Studies are being conducted to evaluate genetic markers or combinations of markers in dairy cattle that are of practical value in identifying cows resistant to mastitis infection, and perhaps, markers related to overall health status. Some of these genetic markers are also related to milk yield and quality, allowing for simultaneous selection for improved production and disease resistance.

**Impact**

The ability to quantify genetic differences among dairy cattle in resistance to mastitis infection would allow for planned matings reducing the incidence of this disease, resulting in improved profitability while also improving the overall herd health status.

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USDA Animal Health Formula Funds; Division of Agriculture, University of Arkansas

## Gene markers increase profitability and sustainability of beef herds

**Issue**

Reproductive rates have the greatest impact on the sustainability and profitability of beef cow-calf operations. During the last 50 years, animal breeding methods have increased cattle growth rates; however, due to the low heritability coefficients for reproduction, their methods have not been effective at improving reproduction. The national average for the percentage of cows that wean calves is approximately 70 percent. Cow maintenance costs vary with each herd; however, annual cow costs are estimated to be between \$200 and \$300. Currently, weaned calves are worth around \$500 each; therefore, increasing the percentage of cows that wean a calf could have tremendous effects on the profitability of cow-calf operations.

**Action**

We have used genomic techniques to identify segments of cattle DNA that are related to calving rates, milk production, and weaning weights of calves. Specifically, we have one segment that indicates that control cows have an 81% calving rate and the alternative cows had an average calving rate of 8%. Another DNA segment is associated with a 50% reduction in somatic cell counts in milk samples. Additional single nucleotide polymorphisms are associated with increased calf weaning weights, feedlot gain, and beef composition and tenderness. These projects were the result of a team consisting of graduate students, undergraduate researchers, laboratory personnel, and scientists in the Animal Science Department and USDA/ARS.

**Impact**

Candidate gene markers will synergize with traditional breeding and selection programs that will result in more profitable and sustainable beef cow herds utilizing toxic tall-fescue forage systems.

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**Funding**

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**Alternative methods to manage the lesser mealworm in poultry production facilities****Issue**

The lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae), also known as the litter beetle, is a small, long-lived beetle with a cosmopolitan distribution. As poultry production moved indoors, the litter beetle became an abundant and serious pest in poultry operations. Adults and larvae feed on spilled grain, feces, and sick/dead birds. Larvae burrow into and cause serious damage to the insulation in poultry houses while seeking a secluded site for pupation. Most important, the beetles are known to transmit a number of pathogens that cause both avian and human diseases.

**Action**

Observations of beetle aggregations suggested that pheromones were secreted by beetles. Our collaborators at the USDA-ARS lab in Peoria, Ill., determined that volatiles are emitted from the beetles and they have identified possible pheromone components from adult beetles. Four male-specific compounds have been characterized: the terpenes, (*R*)-(+)-limonene, (*E*)- $\beta$ -ocimene, and (*S*)-(+)-linalool, and the sesquiterpene, (*R*)-(+)-daucene. No similar compounds have been isolated from the female beetles. In initial pitfall bioassays, we found that male-derived volatiles containing these compounds were more attractive than the corresponding female-derived samples. Behavioral studies continue to determine the importance of these male-secreted pheromones. Field testing of pheromones is planned for 2008.

**Impact**

The identification of these pheromones from the male beetles will be used to develop management methods in which the beetles will be attracted to traps, where they can be killed. The traps will serve to reduce the dependence on repeated treatment of entire facilities with insecticides. The reduction in beetle numbers will also decrease spread of pathogens within the facility and to other facilities, where beetles move during litter removal. In addition, reduction in numbers of adult beetles will also reduce numbers of larvae, thereby reducing damage to insulation in the poultry houses.

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Division of Agriculture, University of Arkansas

**Utilization of distillers dried grains with solubles from ethanol production as a nutrient source for broilers****Issue**

An increasing amount of ethanol is being produced from grain sources in the United States. A byproduct from this is a feedstuff known as distillers dried grains with solubles (DDGS). This is produced first as a wet product that can be fed directly to livestock within a close geographical range to ethanol production plants, or it can be dried to a product suitable for shipping and storage. Although DDGS from beverage alcohol production has been used in poultry diets for many years, the amount used was rather small as percentage of the diet (2-3%). In addition, differences in processing methods make the present-day DDGS somewhat different in composition and bioavailability from the beverage DDGS. As an increasing amount of grain is processed for ethanol production, the poultry industry is faced with using the DDGS effectively as a means of maintaining economical production. Therefore, we embarked on a program of study to evaluate means of effectively utilizing large amounts of DDGS in broiler feeds.

**Action**

Samples of DDGS from ethanol production were obtained and extensively analyzed for total nutrients and estimates of digestibility of amino acids. Feeding studies were conducted to evaluate different feeding scenarios for DDGS to provide maximum usage levels without impairment of performance. It was found that the amino acid digestibility of DDGS was reduced compared to the native corn grain that provided the source of the DDGS, and thus when formulating diets it became important to formulate diets on a digestible amino-acid basis, rather than on the basis of total amino acids as is often done in the U.S. poultry industry. It was also learned that nutritionists must consider a wider range of essential amino acid needs in formulating diets, as corn protein is highly unbalanced in terms of its

amino acid content. It was also found that pellet quality of the diet is extremely important as diets high in DDGS tend to have poor pellet quality, and efforts to improve quality can pay dividends in terms of performance of the chickens.

#### **Impact**

The results of this study provide information to the poultry industry about the potential value of DDGS in broiler diets. This should provide economic benefits both to the poultry industry and to the ethanol industry as a means of disposal of the DDGS that results from ethanol production. As more corn is used for ethanol production, the poultry industry will need new sources of energy for their diets. The inclusion of DDGS should aid in overcoming some of the loss of other energy sources and help maintain a viable poultry industry.

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USDA/CRESS; Division of Agriculture, University of Arkansas

## **Whole-farm profitability of conservation tillage of winter small grains forage production in Arkansas**

#### **Issue**

Winter grazing of stocker cattle on small grains pastures may be a profitable income option for cattle producers in Arkansas. Cow-calf operations account for the majority of cattle operations in the state, with most calves born in the spring and sold at weaning in the fall. Winter small grains forage production may allow some cow-calf operators to retain ownership of their calves beyond the fall or purchase additional calves to be sold in the spring when the winter pasture is grazed out. However, a large portion of land that could potentially benefit from this production system is highly erodible. Also, production of winter small grains forage requires additional machinery and equipment that may not be available on most Arkansas cattle farms. This study evaluates the profitability of conservation tillage winter wheat/rye pasture production and grazing for a 100-head cow-calf operation. The study uses Mixed Integer Programming (MIP) to maximize whole-farm returns and select the optimal machinery complement for hay and winter forage production.

#### **Action**

A 100-head cow-calf operation is modeled using secondary data sources. The model cow-calf operation has 250 pasture acres and harvests its own hay. A stocker enterprise is modeled for the cow-calf operation to allow steers to be grazed on winter wheat/rye pasture from mid-November through April using steer weight-gain data from the University of Arkansas Livestock and Forestry Branch

Station (LFBS) near Batesville. Steer calves in the stocker enterprise are grazed both in the fall and the spring. During the fall grazing period, steer calves from the cow-calf operation may be retained and placed on grazeout pasture with additional steer calves purchased as needed to fully utilize fall grazeout pasture. Additional steers may also be purchased during the spring grazing period to fully utilize spring grazeout pasture capacity. All additional steers are purchased using borrowed capital at 9% interest. The MIP model selects optimal machinery complements for both hay production and winter small grains forage production. Three possible systems are allowed for winter small-grains forage production: Clean-Till (CT); Reduced Till (RT); and No-Till (NT).

#### **Impact**

The results provide evidence that grazing stocker cattle on no-till winter small grains forage can enhance profitability for a cow-calf operation. The NT method is always chosen as the optimal method of winter small grains forage production, and the farm operator may hold steer calves beyond weaning and graze them on winter grazeout pasture for sale in the spring rather than in the fall. However, the whole-farm profitability of grazing stocker cattle on no-till winter small grains forage appears to be highly dependent on the amount of capital available for purchase of additional steers. Additional steers must be purchased with borrowed capital to fully utilize available winter forage capacity and achieve maximum returns. Thus the practice may not be profitable in instances where cow-calf operators lack the necessary capital to purchase additional steers.

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#### **Funding**

NRI Competitive Grant; Division of Agriculture, University of Arkansas

## **Water quality in poultry production**

#### **Issue**

Water is the single greatest input into the production of poultry (birds consume approximately 2 pounds of water for every pound of feed) yet the advent of enclosed drinker systems led the industry into a false sense of well being about their water supplies. In addition, consumer demand to reduce antibiotic use in poultry production has left the poultry industry with fewer tools to solve health problems in poultry flocks.



**Action**

By creating awareness in the poultry industry that drinking water systems are dynamic and potentially vulnerable to microbial challenges, producers across the state of Arkansas and the U.S. are solving or at the very least reducing many poor performance issues in broilers and turkeys resulting in thousands of dollars in improved income. In one particular case, growers (Buster and Diana Janes) had done everything asked by the poultry company including facility renovation, yet flocks on their 10-house broiler farm continued to perform well below average. Analysis of the well water supply revealed bacterial contamination plus minerals contaminants such as sulfur and iron that acted as a food supply for the bacteria. The Janes were educated on ways to effectively clean the water distribution system to remove harmful biofilms and then were advised regarding a safe and economical water sanitation system.

**Impact**

The changes implemented on the Janes' 10-house broiler farm improved their annual farm revenue by several thousand dollars. In addition, their company recognized the Janes as the most improved grower of the year. It is imperative that broiler and turkey remain profitable in order to keep the poultry industry economically sustainable and competitive in the global market place. If 50% of the growers in Arkansas were able to improve income by an average of \$5000 per year, total improvement in earned income would be \$20 million.

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Division of Agriculture, University of Arkansas

## **Pulmonary hypertensive responses of broilers to bacterial lipopolysaccharide (Lps) administered by aerosol, intratracheal, or intravenous routes**

**Issue**

Bacterial lipopolysaccharide (LPS, endotoxin) is an integral component of the cell wall of Gram-negative bacteria (e.g., *E. coli* and *Salmonella*). Animals in commercial production facilities are chronically challenged with air-borne Gram-negative bacteria and LPS on respirable dust that can trigger an inflammatory response within the lungs. Symptoms of respiratory inflammation include dyspnea (labored breathing due to elevated airway resistance), hypoxemia (under-saturation of arterial blood with oxygen), pulmonary arterial hypertension (PAH; an elevated blood pressure within the pulmonary arteries), and impaired growth. In order to improve broilers' tolerance to environmental LPS, it was necessary to develop a suitable model for exposing the conducting airways and gas-exchange tissues of broiler lungs to aerosolized LPS.

**Action**

Broilers spontaneously breathing aerosolized LPS for up to 40 min exhibited few overt symptoms, reflecting effective upper airway defenses against this route of exposure. In contrast, a direct intratracheal aerosol spray of LPS triggered dyspnea, hypoxemia, and growth suppression. Broilers reared on new wood-shavings litter in clean environmental chambers did not develop PAH in response to the intratracheal aerosol spray of LPS, whereas broilers raised under commercial conditions including exposure to used litter did develop PAH in response to intratracheal LPS. Broilers pretreated via aerosol inhalation with substances (red food color dyes and propylene glycol, PG) known to sensitize the airways also developed PAH following an intratracheal aerosol spray of LPS, whereas intratracheal LPS did not trigger PAH in broilers pretreated with aerosolized distilled water or yellow and blue food color dyes. These experiments indicate that inhaled LPS, a common air contaminant in commercial broiler facilities, can initiate PAH primarily in broilers whose airways have been appropriately sensitized by previous environmental challenges or by prior exposure to substances such as Red Dye #3 and PG that are known to be capable of priming the airways' responsiveness.

**Impact**

We can use our model to evaluate population differences in responsiveness to inhaled LPS. Broilers that are better able to tolerate aerosolized LPS should be capable of superior performance in commercial broiler production facilities.

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**Funding**

University of Arkansas Animal Health Grant "Respiratory Response of Broilers to Inhalation of Bacterial Lipopolysaccharide (LPS, endotoxin): Development of an Aerosol Inhalation Model and Characterization of Vasoconstrictors Contributing to the Ensuing Pulmonary Arterial Hypertension;" Division of Agriculture, University of Arkansas

## **Transpulmonary pressure gradient verifies pulmonary hypertension is initiated by increased arterial resistance in broiler chickens**

**Issue**

When broiler chickens grow too rapidly, some individuals in the flock succumb to pulmonary arterial hypertension (PAH, ascites syndrome) because their heart is forced to develop an excessive pulmonary arterial pressure (PAP) to propel blood through lungs having an inappropriately elevated pulmonary vascular resistance (PVR). The overall growth performance of broiler flocks potentially can be

improved if the underlying cause of the elevated PVR can be determined. To address this objective, basic research was needed to identify the location within the pulmonary vasculature that offers the primary resistance to blood flow.

#### Action

We compared key pulmonary hemodynamic parameters in broilers from PAH-susceptible and PAH-resistant lines that had been selected by Dr. N.B. Anthony for 12 generations. In the first experiment, we demonstrated that PAP and PVR are higher in broilers from the PAH-susceptible line than in those from the PAH-resistant line, however, the volume of blood pumped through the lungs per minute (the cardiac output; CO) did not differ between lines. Therefore, susceptibility to PAH can be attributed to an elevated PVR rather than to increases in CO. In experiment 2, male and female broilers from the same lines were subjected to cardiac catheterization. Blood pressures were measured in a peripheral vein, right atrium, right ventricle, and pulmonary artery (PAP). The pulmonary venous pressure was estimated as the wedge pressure (WP), and the transpulmonary pressure gradient (TPG) was calculated as (PAP-WP), with PAP quantifying pre-capillary pressure and WP approximating post-capillary pulmonary venous pressure. The combined hemodynamic criteria conclusively characterized PAH-susceptible broilers as having elevated PAP and PVR combined with proportionally elevated TPG values when compared with PAH-resistant broilers, regardless of gender. Accordingly, susceptibility to PAH can be attributed primarily to increased pre-capillary (arteriole) resistance rather than to pulmonary venous hypertension caused by elevated post-capillary (venous and left atrial) resistance. The onset of PAH is attributable to excessive precapillary arteriolar resistance rather than to generalized cardiac decompensation, left atrio-ventricular valvular regurgitation, or congestive heart failure. This new knowledge allows us to focus our future research on factors responsible for increasing the tone of precapillary arterioles within the lungs of broiler chickens.

#### Impact

We can discover the fundamental biological basis for PAH by identifying the factor(s) that increase the tone (state of contracture) of the precapillary arterioles within broiler lungs.

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#### Funding

USDA-CSREES-NRI Grant 2003-35204-13392 "Intravenous Micro-Particle Injections and Pulmonary Hypertension Syndrome in Broilers;" Division of Agriculture, University of Arkansas

## Studies on the dimensions and control of gastrointestinal helminths in poultry and cattle

#### Issue

Gastrointestinal parasitisms of farm animals are the norm. These parasitisms are usually subacute; undetectable to the observer, but tremendously important in regard to animal performance, efficiency, and profitability. Studies are consistently ongoing regarding the current dynamics of these parasitisms in farm animals and the control of the internal parasites (helminths) that inhabit Arkansas farm animals.

#### Action

Several studies have been completed in 2007. Regarding cattle, helminth levels have been shown to be robust. Additionally, control of these parasitisms has been correlated with enhanced breeding efficiency (age and weight at conception) of replacement heifers. Parasite resistance in cattle has also been documented repeatedly and with clarity. Original and generic ivermectin products are unquestionably being resisted. Milbemycin and second-generation benzimidazole parasiticides are still performing *relatively* well. *Cooperia* spp nematodes are the most prominent in resistance.

Regarding turkey infections by *Ascaridia dissimilis*, we have found that: (1) fenbendazole continues to work exceptionally well, (2) lavamisole aids in the control of this parasite but falls short of being truly efficacious, and (3) nitarsone displays anthelmintic properties (some parasitocidal activity but most definitely causative in decreased worm fecundity).

#### Impact

Worms in cattle and poultry decrease feed efficiencies and animal productivities. Use of effective products at strategic times reduces the adverse effect of these parasites, and correspondingly, increases the bottom line for the producers.

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#### Funding

Intervet; Fort Dodge Animal Health; Alpharma; Merial; Division of Agriculture, University of Arkansas



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## Plant Systems

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### Management practices can control false smut and kernel smut

#### Issue

Recent introductions of hybrid and conventional rice varieties with improved resistance and tolerance to primary rice diseases such as blast and sheath blight have prompted farmers to consider reducing their fungicide applications. This trend of reduced fungicide applications is further supported by increases in chemical and application costs and narrow profit margins. Many of the fungicides currently used in rice production are broad-spectrum thus will control a range of diseases much broader than the ones they might be targeted to. When their use is curtailed, there is a possibility that diseases now considered as minor or of lesser importance, that are being controlled by current management practices, will become major disease problems. Two such diseases in rice are false smut and kernel smut.

#### Action

A long-term study that contains comparisons of rotations, tillage, fertility, and variety was selected for initial evaluations. No fungicides were applied to the rice plots in 2006, thus it was possible to compare all treatment combinations. Rice samples from each plot were collected at harvest. These samples were cleaned and evaluated for the amount of false smut and kernel smut found in each sample. Another study that compared flood watering with 'row' watering of rice was also selected for evaluation. Samples were collected from this study in the same way as with the rotation study.

#### Impact

Data collected from the long-term rotation study indicated that for false smut there was a significant decrease in disease incidence in no-till plots when compared to conventional-till plots regardless of variety. Increasing fertility significantly increased false smut. Overall false smut severity was significantly higher in rice grown in a rice-soybean rotation as compared to that grown in a continuous rice rotation. There was no false smut detected in row-watered rice.

Unlike false smut, kernel smut was significantly affected by only variety and fertility. Tillage and rotation did not impact this disease. Increasing fertility increased kernel smut in all varieties. However, that increase was much less in varieties having some resistance to the disease. There was no kernel smut detected in RiceTec hybrid CLXL 730. In a comparison of Wells and Cybonnet, kernel smut was significantly higher in Wells, where it increased dramatically with added fertility.

These results indicate that these are two very different diseases and that farmers can control these diseases through a combination of management practices. Results have also provided sufficient insight to begin a formal variety evaluation process with the possibility of identifying resistance/tolerance in breeding populations.

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#### Funding

Arkansas Rice Research and Promotion Board; Arkansas Soybean Promotion Board; Arkansas Corn and Grain Sorghum Promotion Board; Division of Agriculture, University of Arkansas

### Application of cotton gin waste and recycled cotton bale wrap in ligno-cellulosic composites (lcc)

#### Issue

Two of the major waste streams of cotton cultivation include the ginning waste that comes from cotton gins and the plastic film used for wrapping the cotton bales in the new cotton module builder. Both of these waste streams do not have any other significant application at present. They pose serious environmental issues, such as the fire hazard of gin waste piles, if merely discarded. Therefore, it is necessary to find alternate uses or disposal strategies for these waste materials without adding additional cost to the producers.

#### Action

This research focus is to generate value-added products from the two waste streams of cotton agriculture: the gin waste and bale wraps. Cotton gin waste is rich in natural ligno-cellulosic fibers, which may be used to replace the more expensive wood fiber in composite boards. Similarly, cotton bale wraps may be able to replace part of the high-density polyethylene in composite boards without compromising the mechanical and physical properties of the end products. Therefore, the objective of this project was to evaluate the two waste materials for potential application in ligno-cellulosic composite (LCC) boards. We plan to characterize the burr and linters fraction of the cotton gin trash for chemical and physical properties, manufacture LCC boards with various amount of these waste materials as ingredients,

test them for relevant physical and mechanical properties, and compare them to commercial composites to analyze their suitability in those applications.

#### **Impact**

It is important to protect our environment for future generations and to help rural communities by making agriculture more profitable. The new composites made with cotton gin waste and recycled bale wrap will add value to two of the otherwise waste materials and reduce the environmental impact by removing them from the environment. This new composite will have lower costs because the raw materials are inexpensive. The cotton farmers will benefit from this product by selling the cotton gin waste for a price instead of paying for its disposal. The many wood-plastic composite industries situated in the cotton belt will benefit from this product by substituting the scarce and expensive raw materials with inexpensive and abundant raw materials that are locally available.

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Cooperators

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#### **Funding**

Cotton Inc.; Division of Agriculture, University of Arkansas

## **Flooding to improve rice water weevil management**

#### **Issue**

Rice acreage in Arkansas fluctuates between 1.3 and 1.6 million acres. In recent years, there also have been changes in varieties, tillage and fertilization practices, planting schedules, and loss of pesticides. All changes have provided significant challenges for insect management. The goal has been to develop and implement options for IPM to reduce use of insecticides in rice.

#### **Action**

Rice growers want to know if cultural practices can reduce infestations of rice water weevil. With production costs on the upswing, rice growers will try almost anything to reduce costs. Growers can use cultural practices to reduce insect pests below economic thresholds. One cultural practice that has not been researched is water depth of permanent flood, which could help manage rice water weevils. With the onset of permanent flood, rice water weevil adults are attracted to the field and begin to lay eggs. Previous observations indicated that adults lay eggs in plants of all ages, but the highest larval densities were found in areas with a deep flood.

Research plots of rice were established in which the natural infestation of rice water weevils was monitored and the impact on yields measured. Rice plots had variable flood depths maintained for different lengths of time. For example, a 2-inch flood depth was maintained for 1, 2, 3, or 4

weeks, then increased to four inches, while control plots had a 2- or 4-inch flood maintained for the entire season. Plots were not treated for any insect and were infested by a natural population of rice water weevils. At three and four weeks after permanent flood, plots were sampled for rice water weevil larvae. Standard procedures were used to take core samples and to separate larvae from the soil and plant roots. Plots were scouted for rice blast disease. Grain yields were also taken.

In this study, rice with a 4-inch flood had the highest infestation of rice water weevil larvae; rice with a 2-inch continuous flood and rice with a 2-inch flood for 4 weeks had 33% fewer larvae than the 4-inch flood. Rice with a 2-inch flood for 1, 2, or 3 weeks had 0.5, 16, and 23% fewer larvae, respectively, than the deep flood. All treatments yielded statistically similar amounts of rough rice. No blast disease was noted in any treatment.

#### **Impact**

Growers now have information on the cultural practice of using a shallow flood to reduce rice water weevil infestation without having a detrimental impact on rice yields. A shallow permanent flood for four weeks after the onset would reduce irrigation time, conserve water, and not increase the incidence of blast disease.

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#### **Funding**

Arkansas Rice Research and Promotion Board, Rice Research and Extension Center, University of Arkansas; Division of Agriculture, University of Arkansas

## **Arkansas cotton germplasm lines add improved fiber length, maturity, and host plant resistance**

#### **Issue**

Over the years, germplasm releases by the University of Arkansas cotton breeding programs have generally displayed enhanced host plant resistance, improved yield, earliness, varied morphological traits, and/or enhanced fiber properties. Several of the releases have led to the development of privately owned varieties that are highly adapted to Arkansas conditions. Some more recent releases are being transformed with transgenic genes to produce varieties possessing specific herbicide tolerance and insect resistance. Continued development and release of cotton lines will help Arkansas cotton producers to have adapted, competitive varieties.

#### **Action**

The Arkansas Agricultural Experiment Station released six cotton germplasm lines in 2007. The six lines were derived from crosses made in 1994 and 1996 followed by development and testing. Each line was selected for high yielding capability (multiple in-state and regional tests), yield stability (via yield components), resistance to specific pests, and fiber quality. One of the lines, 'Arkot 9608ne', is



nectariless. Nectaries on leaves and base of flowers attract and supply nutrition to certain insects. The absence of nectaries is a source of resistance to tarnished plant bugs. Three of the released lines, 'Arkot JJ46', 'Arkot 9610', and 'Arkot 9620', have improved fiber length. Longer fiber length is of particular importance to the changing textile industry. The other two lines, 'Arkot 9623' and 'Arkot 9625', are very early maturing. Early maturation is important for adaptation to north Arkansas locations. All of the lines produced yields (over multiple tests) comparable to a common check cultivar. Some lines are more widely adapted than others. Specific host plant resistant has been bred into the lines. The lines and outstanding attributes are:

Arkot 9608neNectariless, fiber length, fiber strength, smooth leaf

Arkot JJ46 Fiber length, micronaire, smooth leaf

Arkot 9610 Fiber length, smooth leaf

Arkot 9620 Fiber length, smooth leaf

Arkot 9623 Lint yield, early maturity

Arkot 9625 Early maturity

Except for Arkot JJ46, the lines are resistant to bacterial blight. All except Arkot 9610 are more resistant to tarnished plant bugs than 'SG 105'. Since the lines were developed from materials that are not common to most commercial cotton varieties, genetic diversity of adapted cotton lines is improved by the release of these lines.

#### Impact

Public and private cotton breeders are using these lines as parents in their breeding programs. Varieties that are developed using these lines should be better adapted to Arkansas and should provide improved host plant resistance and fiber quality.

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#### Funding

Cotton Incorporated; Division of Agriculture, University of Arkansas

## Toward cellulosic-derived biofuels

#### Issue

Although there are roughly 150 corn-to-ethanol plants with a production capacity of 9 billion gallons, there is a need for additional bio-based liquid fuels. The next generation of biofuels centers on the transformation of cellulosic biomass to liquid fuels, such as ethanol or butanol. The objectives of this study are to determine conditions in which cellulosic biomass can be pretreated before being converted to biofuels. This pretreatment step includes the insertion of an extraction operation aimed at extracting valuable phytochemicals from the biomass prior to conversion.

#### Action

Producing biofuels in the saccharification platform implies the release of cellulose and hemicellulose from the biomass by pretreatment with dilute acid or hot water. As a

source of cellulosic biomass, this project focused on *Albizia julibrissin* and switchgrass, and used a hot-water pretreatment at 60 and 120°C. Switchgrass 60°C hot-water extracts displayed interesting anti-oxidant properties, indicating that it could be possible to obtain a high-value phytochemical stream prior to the 120°C pretreatment.

#### Impact

Obtaining such a stream could bring additional value to the biorefinery. Similar work is currently under way with *A. julibrissin* biomass. Hot water pretreatments are currently being examined. This project is ongoing.

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#### Funding

Division of Agriculture, University of Arkansas; Ralph E. Martin Department of Chemical Engineering

## Should all rice varieties be treated with a fungicide?

#### Issue

Azoxystrobin (Quadris) fungicide was introduced in 1997 and has rapidly become the most widely used disease-control product in Arkansas rice. Due to its outstanding effectiveness in test plots and heavy marketing by crop protection companies and farm supply dealers, many growers have adopted the practice of "blanket" spraying, without regard to disease intensity, variety resistance, or other factors. Many growers have been led to believe that fungicides always "pay for themselves" regardless of the situation.

#### Action

We have previously tested the idea that foliar fungicides always "pay for themselves" in Arkansas rice production using field trials, clearly demonstrating that the idea is false. Economic impact of a foliar fungicide in rice depends on many factors including type and intensity of diseases, field microclimate, soil fertility, water management, variety, application timing, and other influences. However, the influence of individual factors—such as variety resistance—on the need (or lack of) for a fungicide in rice production has not been well researched in recent years.

#### Impact

Results from the second year of study show that variety is one of the most important factors in disease control and productivity, often negating the need for "blanket" fungicide applications. Under Arkansas conditions, sheath blight is the only disease that consistently requires fungicide intervention and these studies clearly show that varieties with resistance to this disease typically do not need a foliar fungicide application. Selecting a more resistant rice variety for fields with a history of sheath blight will save about \$25 per acre by avoiding an unneeded foliar fungicide application.

Statewide, growers are currently treating at least 800,000 acres for sheath blight at an estimated cost of \$20 million. By selecting the correct variety for specific field problems and controlling other management factors that favor disease, this figure could easily be cut in half—a \$10 million savings.

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#### Cooperators

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#### Funding

Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas

## New soybean cultivars offer growers high productivity and profitability

### Issue

Soybean is an important commodity in Arkansas and ranks at the top in acreage among all agricultural crops. Over three million acres of soybean are grown each year, generating approximately 110 million bushels in total production and \$750 million in gross income. Choosing a proper variety is one of the most important decisions a grower has to make each growing season. There are many varietal characteristics, such as yield potential, maturity, disease resistance, herbicide resistance, and seed quality, which need to be considered in matching the best variety with a particular cropping system or production environment. The numerous varieties available to Arkansas growers come from publicly funded breeding programs in the southern states and from private companies.

### Action

The long-term goal of our soybean-breeding program is to develop varieties with high productivity and profitability. Our specific objectives for variety development include high yield potential, various maturities, multiple and durable disease resistance, stress tolerance, conventional and herbicide resistance, lodging and shattering resistance, and improved seed quality. We have established a strong breeding program and an extensive variety-testing program to assist our soybean producers in selecting the best varieties to grow. Arkansas soybean producers provide check-off funds administered by the Arkansas Soybean Promotion Board to support the soybean-breeding program.

### Impact

More than 20 varieties have been released from the University of Arkansas' soybean breeding program and had significant impact on Arkansas soybean production. Growing a high-yielding variety does not cost more than growing an average variety. Every bushel of extra soybean yield produced by growing the high-yielding variety is a net income to the growers. Higher yields from new and improved varieties should translate into higher profits for

Arkansas soybean producers, particularly when production costs are high. Varieties with disease resistance and stress tolerance will also prevent yield loss under unfavorable production conditions. In addition, public programs supply thoroughly tested varieties with low-cost seeds that can be saved for planting, which provides additional savings for the growers. Three new conventional varieties (Osage, UA4805, and Ozark) have been recently released to the public. They all have high yield potential, good disease resistance, and excellent local adaptation. Foundation seeds are available for commercial production.

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#### Funding

Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas

## Specialty soybeans add value to the farm

### Issue

Growing an adapted variety with high yield potential is the cornerstone for achieving profitable soybean production. Public breeding programs have played an important role in the yield increase by both releasing varieties and providing parental materials to private seed companies. Private companies often neglect specialty soybean traits that may have a relatively small market and require long-term investment. With the increasing global competition in recent years, soybean farmers need to find ways to cut down the production cost and increase the crop value. If soybean production is to remain profitable, we need to investigate the potential of the specialty soybean market and value-added soybean production.

### Action

The expanding soybean-based food market in Japan and the U.S. has generated considerable interest among soybean producers. The demand for food-grade soybeans has been increasing due to proved and publicized health benefits and nutritional value from soyfood products such as tofu, natto, soymilk, soy sauce, miso, soynuts, edamame, and bean sprouts. A new breeding program has been initiated at the University of Arkansas in an attempt to develop high-yielding specialty varieties with improved seed-quality traits. We focus on breeding and selections for proper seed size, high protein, low fat (low linolenic acid and mid-oleic acid), proper sugar and calcium content, soft texture, high isoflavone content, and lipoxygenase-free quality. Varieties released from this program will be commercialized in Arkansas for production and seeds will be provided to domestic manufacturers or exported to Japan. In addition, we are developing high-protein and low-phytate soybeans for specialty feed that would increase feed efficiency and diminish environmental pollution. Recently, research has been initiated to develop high-oil soybeans for biodiesel production.

### **Impact**

Growing a specialty variety does not require extra production input, but may result in slight yield reduction. However, growers are offered premiums ranging from \$1.5 to \$3.0 per bushel as incentives to produce the specialty seeds. The high-quality food-grade soybeans, produced conventionally or organically, are often sold at a much higher price than regular commodity soybeans. Therefore, every bushel of extra yield would not only generate extra net income from soybean sales, but also gain additional production premiums. In addition, farmers can save seeds from their own crop harvest for planting next season, thereby ensuring identity preservation and reducing/eliminating seed costs. The specialty soybeans will play an important role in expanding the niche markets for soyfood, feed, and nutraceuticals, and therefore enhance overall soybean production.

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### **Funding**

Blue Horizon Inc. and United Soybean Board

## **Ouachita blackberry impacts American market**

### **Issue**

Blackberries continue to expand in domestic markets. This fruit, which was once harvested only in the wild, is now occupying retail grocer shelf space most months of the year based on domestic and imported production. The primary reason that blackberries are a more common item of retail commerce is the development of improved varieties that can be shipped to distant markets. Additional breeding and genetic improvement is increasing grower options for varieties and is a key for this industry to continue to expand.

### **Action**

The University of Arkansas Division of Agriculture fruit breeding program has been working with blackberries since 1964. Repeated cycles of crossing and selection have been carried out to improve many traits including thornlessness, erect canes, and productive plants, along with improved fruit characters such as larger size, increased sweetness, and firm berries that can be shipped. Emphasis on postharvest evaluations has resulted in substantial progress in identifying genotypes with shelf life adequate for distant-market shipping.

### **Impact**

Ouachita blackberry was released in 2003 and by 2007 had become one of the largest-selling blackberries in the United States. Characteristics such as high yields, excellent postharvest performance, sweet berries, and broad adaptation all have contributed to its success. In fact, the popularity of Ouachita winter and spring of 2007 resulted in all plants available for commercial production being sold out in the U.S. Particularly heavy plantings have been made in

Arkansas, Georgia, and North Carolina, along with various other states. This variety plus other varieties developed by the University of Arkansas are making blackberries a high-value, profitable crop for specialty crop growers and providing an expanded market for this healthy, natural fruit.

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### **Funding**

Division of Agriculture, University of Arkansas  
Fruit Variety Royalties

## **Primocane-fruiting blackberries expanding blackberry horizons**

### **Issue**

Blackberry plants are perennial but normally have biennial canes that require a second year to flower and fruit. This biennial cane growth cycle requires two years for production and also provides for a single crop for a grower. This crop normally ripens in the “summer” months, ranging from late May to early August in most of the U.S. Conversely, red raspberries, a cousin to the blackberry, are often produced on current-season or “primocanes.” This type of raspberry has made a major impact on commercial production in the last 15 years as growers have shifted production to primocane-fruiting varieties. This has allowed production to be shifted to late summer to fall, increasing market windows and profits for this crop. A similar genetic innovation in blackberries can have a similar impact for growers and consumers.

### **Action**

The University of Arkansas fruit-breeding program has developed the primocane-fruiting trait in blackberries in recent years and released the first varieties of this type in 2004, Prime-Jim and Prime-Jan. Although these were released primarily for the home-garden market, some cooperative cultural research and commercial trials have been carried out. Prime-Jan has been shown in Oregon and California to produce high-quality fruits in September and October, allowing production of blackberries in a market period when blackberries are usually not available. A key component in these successful trials has been the growing of these cultivars in moderate-temperature environments plus cane-tipping treatments to increase yields. Continued breeding in Arkansas has advanced the primocane trait into thornless breeding selections with improved fruit quality and an increasing level of heat tolerance in the fruits and flowers. Transfer of the excellent fruit quality from the industry-standard thornless varieties is taking place.

### **Impact**

The impact of the primocane-fruiting blackberry has the potential to be as great as that of red raspberry. Fruiting in the fall, scheduled production with cane management and manipulation, and organic production are all options that are unfolding with the development of this new type of



plant. Further genetic advances are providing the basis for a revolution in blackberry production in the U.S. and world.

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#### Funding

Division of Agriculture, University of Arkansas; fruit variety royalties

## Integrated soybean disease management

#### Issue

There are numerous soybean diseases affecting production each year in the state. Diseases vary in incidence and severity depending on the cultivar utilized, production management, and local environment. Control options vary significantly but depend upon incorporating some mix of resistant cultivars, modified cultural practices, or effective fungicides. Researching the various factors involved and assimilating results into recommendations useable for all producers in the state remain a challenge.

#### Action

Division of Agriculture extension and researchers established an integrated soybean disease management program several years ago in an attempt to provide practical research data for soybean disease control, and pulled together all soybean disease research to provide integrated soybean disease management recommendations. Research involved the evaluation of many new soybean cultivars in different disease environments, where disease-reaction data were lacking. Researchers assessed different fungicide rates and timings on different foliar diseases to determine economic benefits. Researchers have collected data from other disease researchers on nematodes, soil-borne and foliar diseases, basic germplasm evaluation, fungicide assessments, and verification field observations.

#### Impact

Results were used to develop integrated recommendations for disease management in Arkansas. Using recommended cultivars, cultural practices, and IPM fungicide guidelines, Arkansas growers could typically save from \$20 - \$80 per acre in input costs or yield, depending on circumstances. In extreme cases, lack of any management attempts for root knot nematode or stem canker can result in near total yield loss; for sudden death syndrome and aerial blight, up to 50% crop loss; for frog-eye leaf spot and soybean cyst nematode, more than 40% loss; and for soybean rust, more than 60% loss. Most growers use these recommendations today, based on successful delivery of the results through numerous grower meeting presentations and inclusion in the annual soybean update report, popular press interviews, and other venues.

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Cooperators

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#### Funding

Arkansas Soybean Research and Promotion Board; Division of Agriculture, University of Arkansas

## Identification of new races of the spinach downy mildew pathogen in the United States and development of molecular markers linked to disease resistance

#### Issue

Downy mildew of spinach is the most economically important disease of spinach worldwide. Accurate identification of races of the pathogen is critical to aid in developing cultivars with resistance to the various races and aiding in global communication regarding the occurrence and frequency of downy mildew races.

#### Action

Our laboratory has focused on developing near-isogenic spinach lines with specific resistance loci isolated in an otherwise susceptible genetic background to aid in the identification of races of the spinach downy mildew pathogen. Furthermore, the near isogenic lines being developed can be used to study the genetics of resistance to this important disease and for developing molecular markers linked to major genes for resistance.

#### Impact

As a result of this research effort, our laboratory has identified 6 of the 10 new races of the downy mildew pathogen worldwide and has developed a molecular marker linked to a disease resistance locus that can be used to expedite the selection process in breeding for disease resistance in spinach.

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## The use of molecular and genetic tools to identify anthracnose pathogens of fruits and vegetables worldwide

#### Issue

Anthracnose diseases, caused by various *Colletotrichum* species, are economically important plant diseases worldwide. The taxonomic species to which isolates belong often is difficult to determine based on traditional taxonomic features. Accurate identification is critical as quarantine procedures affect various affected commodities that are sold and shipped. Furthermore, accurate identification is important for implementing control procedures. A specific effort on pepper anthracnose has been initiated.

### Action

Our laboratory has devoted considerable effort to characterize genetic and molecular diversity with a cosmopolitan species, *C. acutatum*. A geographically diverse collection of isolates from throughout the world from a wide range of hosts has been assembled. Molecular (AFLPs, mtDNA RFLPs, and intron sequences) and genetic markers (sexual and vegetative compatibility) have been developed to characterize inter- and intra-specific diversity.

### Impact

As a result of this research effort, we can more clearly and objectively identify and differentiate closely related species. Also, we have identified a sexual stage of *C. acutatum*, which had not been known to exist. We have been able to demonstrate that this mating population occurs worldwide.

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### Funding

Division of Agriculture, University of Arkansas

## Development of fresh parboiled rice hulls as an alternative to perlite for use in horticultural root substrates

### Issue

Root substrates are used in the production of greenhouse and nursery crops and are designed to provide suitable physical and chemical properties. An important physical property of substrates is air-filled pore space. Perlite is the most common component used to provide this air-filled pore space. However, perlite is expensive and produces a dust that is an eye and lung irritant. Parboiled fresh rice hulls are a milling byproduct of the rice industry. Large quantities of parboiled rice hulls are produced in Arkansas and result in a significant disposal issue for the rice industry. The objective of this research was to develop parboiled fresh rice hulls as a viable alternative to perlite for use in horticultural substrates.

### Action

Over a three-year period, the physical and chemical properties of perlite and parboiled fresh rice hulls were evaluated and compared when used in substrates. Parboiled fresh rice hulls had physical and chemical properties that were similar to those of perlite and were within recommended ranges. Plant production trials were also conducted to demonstrate the efficacy of parboiled fresh rice hulls for providing air-filled pore space. Crops grown in root substrates containing parboiled fresh rice hulls were of similar or higher quality than crops grown in perlite-containing root substrates.

### Impact

As a result of this research, parboiled fresh rice hulls now constitute a value-added product for use in horticultural substrates. Greenhouse growers throughout the U.S. are

using parboiled rice hull as an alternative to perlite, and Riceland is successfully marketing a branded, parboiled fresh rice hull material (PBH) to the horticulture industry.

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### Funding

Riceland, Stuttgart, Ark.; Division of Agriculture, University of Arkansas

## Near Infrared Reflectance Spectroscopy (NIRS) in the study of forest soils

### Issue

Soil sampling and analysis is time-consuming and costly; however, forest soil productivity is managed best when good data on soil chemical and physical properties are available. With new demands for fiber being placed upon forested lands for potential biofuel production, it is important to implement forest nutrition management practices that will both improve or maintain site productivity and preserve water quality and other key ecosystem services. Forest nutrition management can be more precise through the implementation of cost-effective procedures that increase the intensity with which soils are analyzed. Near infrared reflectance spectroscopy (NIRS) is used with increasing frequency in food science, medical sciences, and other disciplines to rapidly and accurately analyze materials based on spectral calibration libraries. Once calibrations/models are developed with data from samples of known chemical and physical properties, near infrared (NIR) spectral models are used to rapidly analyze similar materials without the time commitment and waste stream associated with standard chemical analyses.

### Action

A study was conducted to assess the effectiveness of NIRS modeling for several soil chemical properties using samples collected from across the Ozark Highlands physiographic region of Arkansas. Samples were collected during the spring, summer, and fall to account for temporal variations in the soil chemical properties of interest. Data from standardized chemical analysis procedures were used in the development of NIR spectral calibration curves, and the effectiveness of NIRS modeling was determined on the basis of statistical significance and the percentage of variation in soil chemical properties explained by the spectral data. The soil chemical data and the corresponding spectral signatures were compiled into a calibration library that is in the process of being expanded for a broader range of soils across the state of Arkansas.

### Impact

Several types of chemical bonds are known to resonate with absorption of NIR radiation to a greater extent than other bonds, and many of the bonds found in organic compounds (C-C, O-H, and C-H) resonate well when exposed to NIR radiation. The effectiveness of NIRS models for pre-

dicting elemental concentrations in soil was influenced by the differential influence of NIR radiation on bonds in the soils sampled in the Ozark Highlands of Arkansas. In the surface horizons of a high proportion of Ozark mineral soils, cycling of elemental nutrients between organic and inorganic forms is known to be a significant source of spatial and especially temporal variation in the availability of plant essential elements. The multivariate models developed by regressing spectral data collected against laboratory chemical data provide evidence that NIRS procedures are effective for analyzing several soil chemical properties that are important for managing forest nutrition. Soil N and C were highly correlated with their spectral signatures, with 92% and 88% of their variation being explained, respectively. Although N-H bonds are considered to be highly influenced by NIR radiation, only 51% of the variation in mineral nitrogen in the form of  $\text{NH}_4^+$  was predicted by spectral models.

Calcium and magnesium, which are elements known to cycle rapidly between organic and inorganic forms in Ozark soils, were significantly correlated with spectral signatures, and 88% and 76% of their variation, respectively, was explained through modeling. Several micronutrients, including metals often present in chelated forms, were significantly correlated, but the models were not considered robust since the percentage of variation explained was less than 50%. Soil pH also was significantly correlated with spectral data, and 86% of the variation in pH was explained with the models generated. These results are expected to be due to the relationship of the quantity of O-H bonds present in a sample with differences in soil pH. Due to the effects that pH has on the availability of plant nutrients, liming for the management of soil pH in many regions is a critical component of effective soil nutrient management for both balancing productivity needs and ecosystem services. For a variety of reasons, forest nutrition management generally does not address soil acidity, but the results of this research also may be applied to soils under different land management regimes.

This investigation alone provides no assurance that NIRS will perform equally well in all soils, and additional research is ongoing to address variations in modeling effectiveness in other physiographic regions of Arkansas. However, the results indicate that NIRS has potential for increasing the number of soil samples analyzed for several chemical parameters important for site productivity, and a baseline spectral calibration library has been generated. Spectral analyses of agronomic crops currently are used in some areas as a means to optimize fertilization in accordance with “precision agriculture” practices, and the benefits are both financial and environmental. Due to the differences in silvicultural compared to agricultural practices, opportunities for implementing a “precision silviculture” system must be based upon rapid, accurate, and cost-effective analyses of soils instead of vegetation. Further research is being conducted to develop calibration libraries that correspond with USDA-NRCS soil map units to facilitate the fertility management of forest soils based upon soil individuals that constitute existing soil delineations.

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### Funding

Division of Agriculture, University of Arkansas; Arkansas Forest Resources Center, University of Arkansas at Monticello

## Rice breeding and genetics

### Issue

Recent studies have documented a decline in genetic diversity of modern cultivars. For example, the genetic base of southern U.S. rice was found to be limited to 22 ancestral lines. Lack of genetic variation limits possibilities for breeding advancement especially in biotic and abiotic stress resistance. Continued development of improved rice cultivars is imperative in order to meet changing cultural and marketing conditions in Arkansas.

### Action

U.S. rice cultivars set the standard for quality in long- and medium-grain world trade. Arkansas rice producers provide funding to help support research and extension to continue the advances made in sustainable production of top-quality Arkansas rice. Cooperation with state, regional, and international rice breeding programs provides a source of new germplasm and data to help in evaluation and enhancement of Arkansas breeding efforts. The incorporation of novel rice germplasm into Arkansas cultivars requires careful characterization of the new introductions. Plant pathology, entomology, cereal chemistry, and plant nutrition are taken into account prior to programming crosses. Genetic analysis using molecular marker technology will improve efficiency of gene incorporation. Field evaluation of advanced experimental lines is required prior to release of new cultivars, coupled with recommended management practices. At least 7 to 10 years are required to develop and release a new cultivar.

### Impact

New Arkansas rice cultivars account for about \$66 million dollars a year in monetary gain. Semidwarf cultivars are grown on about 40% of Arkansas rice acreage. Locally adapted semidwarf long- and medium-grain cultivars incorporating novel germplasm can be expected to sustain this impact while helping to minimize producers' costs due to added inputs such as pesticides.

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#### Funding

Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas

## Increasing productivity of teak plantations

#### Issue

An efficient way to increase productivity of teak plantations is to optimize their density. Optimization of stand density is a less intrusive and less expensive way to satisfy the rising demand for wood products than altering site quality by artificial fertilization, bedding, drainage, irrigation, etc.

#### Action

Using practical process models, it is found that the long-term optimal density index for teak plantations in Kerala, southern India, is 475. Analysis of data from the Inventory of Teak Plantations in Kerala-1997, consisting of 1170 sample plots representing teak plantations in Kerala, showed that only 4.8% of the stands have optimal density. Bringing up the density of understocked stands (index less than 400) and reducing the index of overstocked stands can substantially increase productivity of teak plantations. It has been long suspected that understory composed of tolerant species reduces growth of teak. This effect, however, was rarely documented and often disputed. In the developed model, the effect of understory density is described explicitly. It has been found that by controlling understory species in teak plantations, the mean annual increment in volume of teak can be increased by 30%. Removal of understory growth would also lead to social benefits by providing firewood to the local inhabitants in addition to its effects on the growth enhancement of teak trees. Although these results pertain to only one region in southern India, the developed methodology may be useful for other places and species.

#### Impact

Recommendations were made for optimizing stand density of teak plantations, which can increase productivity by 42%.

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Experiment Station (Project "Development of a quantitative basis for management of Arkansas forest stands);  
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## Site-specific Nematicide Placement (SNP)

#### Issue

Cotton is the most important agronomic crop in the southern U.S. with an estimated annual value of approximately \$6 billion. A significant constraint to profitability in the region is yield suppression due to plant-parasitic nematodes. The estimated monetary loss to our cotton farmers last year was slightly over \$300 million. In Arkansas, growers grew about 850,000 acres of cotton in 2007. Of these acres, a conservative estimate based on results of grower-submitted nematode assays indicates about 40% (ca. 340,000 acres) are infested with economically important nematodes. No commercially acceptable nematode-resistant cotton cultivars have been developed for use in this region, so growers rely heavily on annual applications of chemical nematicides. These materials range in cost from \$25-\$45 per acre annually and are all toxic and pose considerable environmental risk.

#### Action

In 2001, researchers initiated a multi-state (Arkansas, Louisiana, Missouri, South Carolina) cooperative effort to study the potential of certain precision agriculture technologies and strategies as related to more precise and profitable placement of nematicides within individual fields. These investigations have demonstrated that soil type and texture are primary factors in determining both the distribution of nematodes within production fields and their damage potential for the crop. Soil electrical conductivity (EC), which is highly correlated with soil texture, can be easily and economically measured and mapped within individual production fields using mobile EC meters. This work has shown that these maps can then be used both to focus ground-truthing (nematode sampling) to determine nematode-induced crop risk and to deliver nematicides at appropriate rates site-specifically only to those areas within fields where uncontrolled nematodes will result in economic yield loss. Studies in production fields in Arkansas, Louisiana, and South Carolina over the last three years indicate that it is possible to identify zones within fields where nematodes occur at economic levels, and to deliver nematicides at effective rates specifically to these zones. It appears that using this approach may result in a decrease in nematicide application (and expense) of at least 30% while maintaining acceptable yields. This year, researchers introduced the concept to cotton farmers and consultants in Arkansas and Louisiana under the name Site-specific Nematicide Placement (SNP). Two hands-on workshops (Portland, Ark., and Winnsboro, La.) were conducted to introduce the concept.

#### Impact

The SNP system can significantly improve the profitability and lower the environmental impact of nematicide use in cotton in the southern U.S. Nematicide use reduction on an individual farm and field basis will depend on the severity of



the nematode problem. Estimates in Arkansas and Louisiana during the last two years in a pilot program, however, indicate that at least 30% of the nematicide that is routinely applied is unnecessary. A conservative estimate in Arkansas alone would be a savings of about \$3.1 million each year for our cotton producers.

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#### Funding

USDA Initiative for Future Agricultural and Food Systems; USDA Natural Resources Conservation Service; Dow AgroScience; Bayer Crop Protection; Division of Agriculture, University of Arkansas

## Arkansas growers produce record yields growing blast-susceptible rice varieties

### Issue

Historically, unpredictable blast disease frequently devastates rice in U.S. rice production areas with total yield loss observed in very susceptible varieties. Rice blast is primarily controlled using resistant varieties, cultural practices, and fungicides. The most obvious and widely recognized form of variety resistance occurs when one or more major resistance genes (R-genes) confer immunity to the blast disease. Unfortunately, R-gene varieties are often quickly overwhelmed by new and/or unexpected variants of the rice blast pathogen, *Magnaporthe grisea*. In contrast, a more sustainable rice blast field-resistance is available through the combined action of multiple major/minor resistance genes. Field resistance allows the plant to become diseased and is adversely impacted by field conditions. When rice blast is controlled, modern susceptible varieties typically out-yield R-gene-resistant varieties by 5 to 10%. Growers can alter various cultural practices to lessen the occurrence and impact of diseases. Fungicides are often not efficacious, and are expensive and difficult to utilize.

### Action

Arkansas rice growers and scientists long observed extensive blast damage in plants growing under dryland con-

ditions, such as on the tops of levees and in higher areas of a field with inadequate soil moisture, while nearby plants growing in the flooded parts of the paddy were healthy.

Field observations were documented by research into proper water management practices. A continuous deep flood was determined to be an effective blast control strategy in susceptible varieties. The UA Extension Service, using research results, showed growers how to use flood depth to minimize rice blast in the state. This has reduced the need for Arkansas farmers to use highly resistant but lower yielding varieties and allowed them to grow higher-yielding rice varieties that vary in blast susceptibility. Today, about 80% of the state acreage is planted to blast-susceptible rice varieties, including ‘Wells’ and ‘Francis’, with little or no use of fungicides. In addition, the water management techniques aid breeder development of varieties and germplasm with increased blast field-resistance.

Continued research identified root-zone dissolved oxygen (DO) as the mediating variable for blast field-resistance mechanisms. DO content defines availability of plant nutrients and root production of hormones, primarily ethylene, which determine susceptibility to rice blast. Plants grown in flooded conditions have well organized leaf-vein vascular bundles, which inhibit fungal growth. Drought stress compromises efficacy of R genes, such as Pi-ta, currently available in Arkansas and other rice-producing states. Research scientists manipulated this knowledge to prevent or greatly reduce the incidence of rice blast in Arkansas while selecting varieties with even higher levels of field resistance.

### Impact

Grower acceptance of recommended fertility, irrigation, and disease-scouting practices based upon these scientific concepts and results has reduced disease incidence and severity.

Proper irrigation procedures are the primary blast-control strategy utilized by Arkansas growers and are now accepted as efficacious blast control by rice research scientists in the U.S. During blast conducive years 2001-2007, Arkansas rice growers used flood management and other cultural practices to produce record per-acre and statewide rough-rice yields growing very high-yielding, blast-susceptible varieties. When grown blast disease-free, the susceptible cultivars yield 5 to 30 more bushels of rice per acre than available R-gene resistant varieties. At an estimated value of \$5 per bushel, this additional yield provides approximately \$25 to \$150 increased per-acre income in over 80% of Arkansas rice acres. A production cost reduction of \$35 to \$70 per acre is realized from reduced fungicide use, which in turn lowers the pesticide load on the environment.

By its parasitic nature, the blast fungus must adapt by evolving new races to overwhelm R-genes. Apparently, there is less pressure to evolve new races with field-resistant varieties when growing in flood conditions. As a result, the erratic nature of the disease has been moderated. Although identified in 1993, a potentially damaging blast race, IE-1k, was held in check in susceptible varieties by root zone-induced field resistance until 2004 when the ‘Banks’ cultivar



was released. Although all Arkansas varieties are susceptible to race IE-1k blast, the disease does not occur in these varieties when growing in flooded conditions.

In addition, long-term benefits will accrue as plant breeders utilize the research to develop even higher yielding field-resistant varieties.

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#### Funding

Division of Agriculture, University of Arkansas; Arkansas Rice Research and Promotion Board

## Dynamic rice diseases demand diligence

#### Issue

Rice diseases are difficult and expensive to manage. Many disease-causing fungi, such as the rice blast pathogen *Magnaporthe grisea*, easily adapt to attack disease-resistant varieties. Research is required to monitor rice diseases and develop effective disease management programs using combinations of genetic resistance, cultural practices and fungicides.

#### Action

Arkansas rice pathologists routinely evaluate newly acquired germplasm of *Oryza sativa* and related *Oryza* sp. in an effort to identify and define new disease-resistance genes. Existing and novel desirable genes are utilized by plant breeders to develop improved varieties. Rice pathologists define existing resistance genes and discover novel resistance genes, provide research data about the optimal cultural practices necessary for disease control in susceptible varieties, and extend utility of available resistance genes. Arkansas rice varieties have excellent yield potential in the presence of the state's two most costly diseases—sheath blight and blast. Researchers continually test and verify recommendations for managing diseases using resistant and susceptible varieties, proper cultural practices, and, as a last resort, fungicides.

#### Impact

Using high-yielding, disease-resistant Arkansas rice varieties, rice growers produce record rough rice yields while reducing production costs by as much as \$70 per acre by eliminating the need for costly fungicides. Producers also are provided the technology necessary to manage disease-susceptible varieties having very high yield potential when diseases are controlled.

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#### Funding

Division of Agriculture, University of Arkansas; Arkansas Rice Research and Promotion Board

## Butterfly Bush hybrids will boost producer markets

#### Issue

Butterfly bush (*Buddleja davidii*) is a low-maintenance, long-flowering shrub commonly found in the Arkansas landscape. However, this species is a tetraploid having four sets of chromosomes. Other desirable *Buddleja* species and hybrids are diploids and have two sets of chromosomes. Because of the differing chromosome number between these two groups of *Buddleja*, it is difficult to obtain useful hybrids when crossing between them. Creation of new hybrids through interspecific hybridization will increase the popularity of these plants and offer additional flower colors and foliage forms not typically seen in *Buddleja davidii*.

#### Action

Oryzalin treatments in combination with plant tissue culture were used to double the chromosome number of an orange-flowered diploid *Buddleja* hybrid (*madagascarensis* × *crispa*). This hybrid also features attractively pubescent silvery-green foliage. These plants, now tetraploid, were then successfully hybridized both with *Buddleja davidii* and other tetraploid *Buddleja* species. Second-generation seedlings obtained from the initial hybrids exhibited a wide range of new flower colors and foliage types. Included were plants with bi-colored flowers, increased petal numbers as well as plants with striking silvery foliage.

#### Impact

The ability to convert diploid *Buddleja* hybrids and species to tetraploids combined with subsequent hybridization has allowed for the development of new ornamentally attractive butterfly bushes. The ease with which these chromosome numbers were manipulated may allow this technique to be used with other ornamental plants. The development of new hybrid plants will assist Arkansas-based producers of ornamental plants in the production of novel plant material suitable for use in Arkansas and elsewhere in the United States.

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#### Funding

Division of Agriculture, University of Arkansas

## Seasonal ecology and impact of insects on management of Arkansas pecan

### Issue

Pecan growers in Arkansas have traditionally relied on other states for extension and research information on insect control. As a result, in 2004 we initiated studies to better understand the seasonal abundance and management of pecan insects. Efforts were intended to help us understand the need for more formal research and extension efforts. Observations were concentrated in southwestern Arkansas, but the expanding Arkansas Pecan Growers Association and grower awareness of an expansion of activities created a need for information throughout the state.

### Action

For the past four years, we monitored pecan nut casebearer, stinkbugs, and pecan weevils and tracked fruit set and retention across multiple orchards in Little River County, Ark., along the Red River. This information has stimulated interactions with growers, as has the newly formed Arkansas Pecan Growers Association. More elaborate study of the data and observations of a diversity of different grower approaches to pecan insect management strongly suggest that additional educational efforts are needed. Many of the technologies and strategies for managing pecan insects in other states would be applicable to Arkansas, but the information needs to be better organized and updated. The specific applications to Arkansas' diverse production regions also need more study and description. In 2007, we submitted a revision of the recommendations for pecan insect control in Arkansas (MP 144), and we formally joined a southern regional project on pecan insect management to further expand our knowledge of management approaches. The interaction with entomologists and horticulturalists in other states will facilitate a more efficient compilation of information and research needs for Arkansas.

### Impact

Practical outcomes of the effort include expanded collaboration with the Arkansas Pecan Growers Association, revised insect-control recommendations, cooperation on regional efforts to detect new pest species and hone management decisions for traditional pests like pecan nut casebearer, and expanded knowledge of the scope and importance of insects attacking Arkansas pecan. The collaboration of research and extension entomologists and horticulturalists will yield opportunities to enhance pecan management in the state. We are interested in better understanding the geographic diversity of pecan production and pecan insects as a first step in the process, and we hope to attract funding to support the effort. Our initial activities should be a base for building this effort.

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Division of Agriculture, University of Arkansas  
Agricultural Experiment Station; University of Arkansas  
Cooperative Extension Service

## Development and implementation of IPM programs for insects on Arkansas vegetables

### Issue

*Impact of insects on commercial vegetable production.*  
Of the more important commercially produced vegetables in Arkansas, insects severely affect squash, eggplant, snap bean, spinach, greens, and cowpea. Previously, management of insect pests was based entirely on chemical insecticides applied when plants reached specific developmental stages. Although insecticides were repeatedly applied to manage squash bug, little control was obtained. Snap beans were sprayed at first bloom and every week thereafter; spinach received an insecticide application when plants were in the 2-inch rosette; and cowpea seedlings were sprayed when damage appeared, regardless of presence of insects. Little to no effort at scouting for insects was made in Arkansas vegetable crops. As a result, insecticides were applied when insects were not present or when the least-susceptible stages were present. This management approach increased costs of chemicals (\$5 to \$10 per acre) and application (\$3 to \$5 per acre). Multiple applications per season increased these costs further. Additional problems included increased applicator exposure to chemicals, potential environmental hazards, and the potential for insects to develop resistance to synthetic chemicals.

### Action

*Improvement of insect scouting, management strategies.*  
Recent studies have demonstrated the effectiveness of new insecticide seed treatments on cowpea and spinach. Studies have been conducted during the past five years to further define the biology of the corn earworm and European corn borer on snap bean. Sampling techniques and thresholds have been developed and are currently used throughout the region (west Arkansas, northeast Oklahoma and southwest Missouri) for corn earworm larvae. Studies also produced a better method for detecting European corn borer larvae in snap bean seedlings (plant flagging) and adult European corn borers with pheromones in pheromone traps. These monitoring strategies are now used in decision-making in all snap beans produced in the three-state area.

### Impact

*Improved insect management, cost reduction, increased applicator safety, reduced environmental hazards.*  
Alternatives to foliar insecticide sprays for aphid management on spinach are now available and in use in the Arkansas River Valley. Strategies are now in place to efficiently manage the corn earworm and European corn borer in spring snap bean in the three-state area. Producers of snap bean that followed these practices reduced insecticide

use by 40% with no reduction in snap bean quality. Additional benefits include reduced exposure to insecticides during application by producers and pilots and reduced environmental hazards. Squash and pumpkin producers now have a method of managing squash bug.

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#### **Funding**

Allen Canning Co.; chemical cos.; IR-4 Program of USEPA; Division of Agriculture, University of Arkansas

## **Understanding changes in private forest landowner management behavior while facing uncertainty from the red oak borer**

#### **Issue**

During the past few years, oak forests in the Arkansas Ozarks have been severely decimated by an insect pest commonly referred to as the red oak borer. According to the U.S. Forest Service, 350,000 acres of the Ozark-St. Francis National Forest in northwest Arkansas have been severely impacted (that is, more than 50% of oak trees are dead or dying), while another 325,000 acres are estimated to have moderate levels of damage. Approximately 58 percent of the forests in Arkansas are owned by more than 200,000 non-industrial private forest (NIPF) landowners. NIPFs are by far the largest ownership group in Arkansas. With supply from public forests dwindling due to environmental concerns, NIPFs are increasingly becoming the most important component in meeting the nation's demand for wood fiber, clean water, aesthetics, biodiversity, and recreation. For this reason, oak mortality in northern Arkansas can have a substantial impact on the local and state economy. This fact emphasizes the importance of research on red-oak-borer impacts on private forests. The objectives of this research project were to understand the extent of NIPF landowners' knowledge on oak mortality and to understand change(s) in landowner forest management behavior due to the threat of red oak borer infestation and associated economic and policy impacts.

#### **Action**

A mail survey was designed following the Tailored Design Method recommended by Dillman (2000) and was conducted between November 2006 and January 2007. Fifteen hundred landowners were randomly selected for the final survey. Because severe oak decline was observed since 1999, landowners were asked if they had conducted any harvest activity within the last seven years. The questionnaire included questions on characteristics of the forestland, level of knowledge of the red oak borer, past harvesting activity, risk perception of forestland being infested by red oak borer, and basic demographics. The data collected from this survey were then analyzed using a variety of statistical methods.

#### **Impact**

The results of the study showed that the level of knowledge about the red oak borer was generally low among NIPF landowners. Landowner sources of information varied depending on their residence (urban or rural) and management objectives. The results from our study also suggest that targeting different outreach methods (personal communication, mass media, etc.) for landowners based on their ownership objectives may be useful to stimulate forest management. Results from statistical models investigating the influence of risk and uncertainty on forest management indicate that both stand characteristics and ownership characteristics help shape the risk perception of forest landowners.

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#### **Funding**

U.S. Forest Service; University of Arkansas at Monticello Faculty Research Fund; Division of Agriculture, University of Arkansas

## **Managing stripe rust and head blight diseases of wheat**

#### **Issue**

Stripe rust and head blight are two diseases that threaten wheat production and utilization nationally and worldwide. Recent changes in the population of the stripe rust fungus expanded the geographic range where stripe rust occurs and led to more severe disease and greater yield and quality losses. Although head blight reduces yield, the major concern related to this disease is the level of mycotoxins in harvested grain. Deoxynivalenol is the toxin most commonly associated with affected grain, but isolates of the pathogen that produce nivalenol rather than deoxynivalenol have been found in Arkansas, and nivalenol is more toxic than deoxynivalenol.

The worldwide trend has been to require lower levels of mycotoxins in grain to protect human and animal health, and achieving these lower levels will require greater efforts to manage head blight.

#### **Action**

The UA Wheat Pathology Program contributes to the national effort to manage both of these diseases by developing germplasm lines with resistance, evaluating breeding lines and cultivars for resistance, characterizing resistances that appear to be most useful, investigating phenotypic and molecular variation of the pathogen populations, and developing chemical control strategies. The Program has also established working relationships with European scientists who have similar interests.

#### **Impact**

Growers are able to select cultivars with resistance to these diseases and to use effective fungicides when these diseases threaten their crops. Investigations of the phenotypic and molecular variation of the stripe rust fungus have led to

a better understanding of the recent stripe rust epidemics. Graduates students have been educated to conduct research on these diseases.

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Vegetable Substation; University of Arkansas Farm; Robert Bacon and Rick Cartwright

#### **Funding**

Arkansas Wheat Promotion Board; U.S. Wheat and Barley Scab Initiative; U.S. Stripe Rust Initiative; Division of Agriculture, University of Arkansas

## **Arkansas farmers produce more than 45 percent of the rice grown in the United States**

#### **Issue**

Arkansas farmers produce more than 45% of the rice grown in the United States under dynamic production conditions that differ from those in other rice-growing areas. Because of their prominence in this crop, Arkansas rice farmers depend on an Arkansas variety development program that provides a progression of improved varieties to meet the challenges of changing conditions in their fields and in the marketplace for rice.

#### **Action**

Arkansas rice producers provide check-off funds administered by the Arkansas Rice Research and Promotion Board to help support a dynamic rice breeding program by Arkansas scientists in cooperation with researchers in other states and the USDA. Check-off funding for the breeding program was started in 1980 and has increased substantially over the years. Nineteen varieties have been released from the Arkansas breeding program since 1980. Each variety comes with management recommendations developed through research on plant nutrients, diseases, insect pests, weeds, and other areas. These recommendations help farmers tailor practices to the genetic potential of each variety. Genetic improvement in disease resistance, plant types, grain and milling yields, quality, and other traits have helped increase yield and grain quality while controlling production costs.

#### **Impact**

Fifty percent of the rice grown in Arkansas in 2007 was comprised of varieties developed in the Arkansas rice variety improvement program. When the program was started in 1980, the average rough rice yield in Arkansas was only 4,110 lbs/acre compared to 7200 lb/acre in 2007, which is the highest state average yield in Arkansas history. Assigning a conservative value of 60% of this 3090 lb/acre yield increase to new varieties, the average monetary gain in 2007, at a rough rice price of \$10.00/cwt, would be \$185/acre or \$246 million for the 1.325 million acres grown in Arkansas, of which \$123 million is due to the Arkansas breeding program varieties.

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#### **Funding**

Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas

## **Can Asian soybean rust be managed effectively through a statewide monitoring program?**

#### **Issue**

In November 2004, Asian soybean rust spores were moved into the United States from South America by Hurricane Ivan. The disease was detected on late-maturing soybean plants in 9 states, including Arkansas, but was winter-killed to central Florida. In 2005 and 2006, a major drought kept the disease from expanding northward, although the southeastern U.S. had diseased soybeans later in the season. Nevertheless, the pathogen was able to spread throughout the Gulf Coast over the last few years, increasing its overwintering area. With early detection and warning, Arkansas growers can respond appropriately with fungicides and hopefully protect our yield potential as well as slow the northward progression of the disease into the Midwest. Yield loss estimates for the southern U.S. from an uncontrolled soybean rust epidemic remain in the 50% range.

#### **Action**

The soybean rust working group worked with national, state, and local groups to monitor the movement and development of soybean rust from the Gulf States into the central United States, including Arkansas. In Arkansas, the monitoring program consisted of 22 soybean sentinel plots and multiple Kudzu plots that were sampled every week for the presence of soybean rust. All data and information gathered each week were disseminated through state and national information networks to producers in Arkansas and surrounding states. Dissemination of accurate and timely information has remained the key component in managing an outbreak of soybean rust.

#### **Impact**

In 2007, soybean rust was confirmed in Arkansas in July in soybean sentinel plots and grower fields in Little River County. This confirmation was almost 3 months earlier than in 2006. Dry weather in August delayed the development and spread of soybean rust into other soybean-producing



counties. By the end of the season, soybean rust had been confirmed in 33 counties. Fortunately, the monitoring program aided in providing the timely information needed for growers to make effective management decisions. It is estimated that Arkansas producers only applied fungicides to control soybean rust on 200,000 acres (7% of total acres) as a result of the monitoring program. If normal weather conditions had prevailed during August, the disease would have likely been more severe, creating a major problem for growers in Arkansas, surrounding states and the central Midwest.

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#### **Funding**

Division of Agriculture, University of Arkansas Cooperative Extension Service; USDA; Arkansas Soybean Promotion Board

## **University of Arkansas Southernpea breeding program**

#### **Issue**

The University of Arkansas Southernpea breeding program has a long and successful history in variety development and to date the program has released 16 varieties, many of which have been very successful as varieties for the processing industry. The processing industry has the ability to contract for seed production, so seed availability is not a significant issue. However, these varieties are not readily available to fresh market growers and home gardeners.

#### **Action**

A major seed company had expressed interest in Arkansas varieties and also expressed interest in Arkansas material but wanted to be able to have exclusive rights to material to qualify a marketing campaign. Utility patents were obtained for 3 Arkansas breeding lines and the right to market these varieties was granted to the seed company.

#### **Impact**

The 3 varieties are currently being marketed as 'Top Pick Pinkey', 'Top Pick Cream', and 'Top Pick Brown Crowder'. Commercial qualities of seed are now available that can be purchased by fresh market producers and home gardeners so Arkansas genetics are now available to Arkansas growers.

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## **Adding value for the regional grape and wine industry**

#### **Issue**

Many small- to medium-sized farms are finding it difficult to maintain economic viability through a traditional focus on livestock, poultry, or agronomic crops. Increasingly, these farms are exploring alternative or non-traditional crops as a way of increasing profitability of their farming operations. Wine and juice grapes are one alternative that hold considerable promise. On a per-acre basis, vineyards can command returns that greatly exceed returns from conventional crops. Furthermore, grapes provide tremendous potential for value-added marketing opportunities at the farm level, thereby increasing the farmer's share of the consumer's dollar.

#### **Action**

With the aid of funding from the USDA, UA scientists are developing a comprehensive set of materials to address challenges confronting vineyard operators, processors, and wineries. These emphasize good agricultural and handling practices for grapes, yearly timetables for vineyard operations, and the economics of establishing and operating vineyards. Significant progress has been made toward completing easy-to-use budget templates that integrate a variety of economic and viticultural considerations and facilitate decision making by those new to the industry. In particular, insecticide and fungicide spray recommendations provided by cooperative extension services throughout the South and Midwest are being incorporated into the budget templates to provide a user-friendly means of evaluating the costs of different insect- and disease-control strategies. In February 2007, project participants presented findings on vineyard economics to several hundred participants at the Midwest Grape and Wine Conference. Work is also being done to address retail markets for grapes and grape products; assess the potential of high-value products derived from grapes and grape by-products; and provide fundamental information about the legal, business, and technical aspects of establishing and equipping a winery.

#### **Impact**

There is considerable interest in grapes and wine on the part of potential growers, entrepreneurs, and consumers. The promise of this industry for agriculture in the South and Midwest is tremendous in terms of a high-valued alternative crop for producers, the ability to add value locally, and the economic opportunities in rural areas that can be provided by farm-based wineries and processing enterprises. The impact of this project is to ensure that information and timely assistance are available to promote the development and increase the successes of the regional grape and wine industry.

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### Funding

USDA CSREES National Research Initiative Grant # 2006-55618-17203; Division of Agriculture, University of Arkansas

## Increase efficacy, economic viability, and sustainability of a total vineyard mechanization system

### Issue

According to the National Grape and Wine Initiative, the U.S. grape industry has an annual economic impact of \$50 billion. Growers of premium wine grape varieties rely heavily on hand labor in vineyards with labor accounting for as much as 75 to 85% of pre-harvest costs. Scarcity and increased cost of labor along with increased competition from producing regions overseas (some with much cheaper labor) have caused growers to examine various forms of mechanization in the vineyard in order to remain competitive in the grape and wine market. Harvest mechanization has been available commercially since the late 1960s. However, traditional vineyard operations along with the large number of grape species, trellising systems, and their combinations have impeded the progress of overall vineyard mechanization.

### Action

Since 1966, a great deal of research by the University of Arkansas Division of Agriculture has been dedicated to defining factors affecting vineyard uniformity and designing total grape vineyard mechanization systems that optimize yield without detrimental effects on grape juice or wine quality. The Morris-Oldridge Total Vineyard Mechanization System was patented in 2002. Large-scale research studies to verify the commercial effectiveness of this M-O System have been underway in California since 2002. The impact of total vineyard mechanization on the raw product quality and on final juice and wine quality has been continually assessed. Maintenance of yield and fruit quality has been demonstrated while reducing costs by as much as 70%. Machine farming is more consistent than hand farming. With the goals of balancing the crop and optimizing yield and fruit quality in a specific vineyard, the "balanced cropping" achieved with mechanization has actually provided an average increase in yield of 26% and allows maintenance of this consistently higher yield. This ability to produce a consistent annual yield may have equal or greater economic impact than the labor-saving aspect of mechanization. Additional years of research on these plots will allow verification of these trends as well as provide an opportunity to study the long-term effects of mechanization on vine vigor and fruit quality. Work continues on efforts to apply the M-O System to additional trellis systems and cultivars. The quality of wines made from grapes produced by machine vs. hand methods continues to be investigated. Analyses are run to determine chemical and sensory quality. Chemical analyses include determination of

alcohol, °Brix, carbon dioxide, volatile acidity, tannins, phenolics, and anthocyanins using standard procedures. Sensory analyses are also done on the wines. No diminution of quality has been detected in wine from machine farmed grapes, with those wines in fact being more favorably evaluated in some cases.

### Impact

The cost savings that can be realized from mechanizing pre-harvest operations are economically important. Our published work indicates that these cost savings can be estimated at \$273 per acre on a Vertical Shoot Positioned trellising system (VSP), \$529 per acre on a Two-foot Lyre, and \$612 per acre on a Quadrilateral. Implementation of the M-O System has reduced costs by as much as 70%. Perhaps most importantly, these savings have been obtained while maintaining yield and fruit quality. In addition, the use of mechanized production systems has the potential to stabilize grape yield and supply for wineries through the concept of "balanced cropping." This aspect of the M-O System, the ability to produce consistent annual yields, may have equal or greater economic impact than the labor-saving aspect. The vineyard data have shown that commercial mechanization systems can be used by growers to successfully achieve the yield, quality, and canopy management goals that are expected of them by wineries. Widespread implementation of total vineyard mechanization will save grape growers tens of millions of dollars annually.

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### Funding

USDA/CSREES; Missouri Wine & Grape Board; Division of Agriculture, University of Arkansas

## Broadleaf and grass weed control on rice levees

### Issue

Weeds continually emerge on rice levees due to moist conditions and the absence of a flood on top of levees. This presents rice growers with weed management difficulties different from those in flooded bays. In a recent survey, consultants noted that broadleaf and grass weed control on levees was one of the most challenging weed management issues they face in rice each year.

### Action

Broadleaf weed control was evaluated on levees in experiments conducted at Stuttgart and Lonoke, and a grass control experiment was conducted on rice levees at Stuttgart. Hemp sesbania, prickly sida, palmleaf morning-

glory, and Pennsylvania smartweed were present in the broadleaf experiments, and large crabgrass, barnyardgrass, and broadleaf signalgrass were present in the grass trial. The effectiveness of individual herbicides and tank mixtures with propanil and quinclorac were evaluated in the broadleaf trials. In the grass trial, fenoxaprop and cyhalofop were evaluated alone and in combination with propanil and quinclorac at two spray volumes.

#### **Impact**

Tank mixtures containing 2,4-D provided the most consistent control across broadleaf species. However, 2,4-D is not an option for rice growers in some areas of the state. In those areas where 2,4-D use is prohibited, other herbicide mixtures will have to be used that are narrower in spectrum of control. In the grass trial, it was found that quinclorac needed to be a component of all tank mixes because of its residual grass control. Fenoxaprop and cyhalofop provided a high level of initial control but additional grasses emerged because of the absence of residual control. Findings from this research will be added to the MP44 (weed control recommendations) to allow producers to best match levee weed control programs with their weed spectrum.

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#### **Funding**

Division of Agriculture, University of Arkansas; Rice Promotion Board

## **Comparing weed management programs in furrow-irrigated and flooded rice**

#### **Issue**

Rice is mainly grown in Arkansas using a permanently established flood at the 5- to 6-leaf stage of rice. Water demands are great and declining aquifer depths have increased irrigation pumping costs in some areas of the state. Furrow-irrigated rice is one potential alternative that may be able to reduce water use; however, no research has addressed weed management issues that may arise in a furrow-irrigated system.

#### **Action**

Twelve weed management programs were compared between furrow-irrigated and flooded rice culture on silt loam (Pine Tree) and clay (Keiser) soils. The weeds of flooded rice were also problematic in furrow rice. Additionally, weeds such as Palmer amaranth, prickly sida, and morning-glories, which are not problem weeds of flooded rice, were problematic in the furrow-irrigated system. In a separate trial at both locations, higher than recommended seeding rates in furrow-irrigated rice were investigated as a means to increase the rate of rice canopy formation and reduce the need for herbicides.

#### **Impact**

As a result of a more diverse weed spectrum and prolonged need for weed management, herbicide use in furrow-irrigated rice was approximately twice that in a flooded system. Because of the absence of a permanent flood, residual herbicides had to be relied upon throughout the season in the furrow-irrigated system. The additional cost of herbicide is likely offset by the savings in water consumption needed to produce the crop. On the clay soil, furrow-irrigated rice required 35% less water than bay rice. Rice yields in the furrow-irrigated system were slightly (5 to 10%) less than those in the flooded system. For hybrid rice, seeding rates above 30 lb/acre did not contribute significantly to improving weed control and the higher seeding rates would be an added cost to producers. It was concluded from this research that weeds can be effectively managed in furrow-irrigated rice; however, the intensity of weed management will exceed that of flooded rice.

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#### **Funding**

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## **Rice cutgrass: An increasing problem weed of rice**

#### **Issue**

Rice cutgrass is a perennial, rhizomatous weed that is increasing in occurrence in zero-grade fields where rice is grown continuously.

#### **Action**

Greenhouse and field trials were conducted to determine what herbicides would provide effective control of rice cutgrass. Field trials were initiated at Stuttgart to determine the rate of expansion of rice cutgrass and the degree of rice yield loss caused by interference from rice cutgrass. Plots were established this fall to develop late-season management strategies that producers could use to reduce the occurrence of rice cutgrass in the subsequent rice crop.

#### **Impact**

The greenhouse study revealed that rice cutgrass is extremely tolerant to most rice herbicides, including quinclorac, clomazone, propanil, fenoxaprop, thiobencarb, and cyhalofop. In field trials, multiple applications of imazethapyr provided complete control of rice cutgrass, and a single application of bispyribac-sodium provided suppression. These two herbicides will provide rice producers an option for managing this weed in continuous rice fields in the future. Although not labeled in rice, glyphosate and glufosinate were effective in controlling rice cutgrass and could be used for controlling this weed prior to seeding rice or fol-

lowing harvest. A single rice cutgrass shoot established shortly after rice emergence expanded approximately 1 ft in all directions during the cropping season. The expansion rate for rice cutgrass in the absence of rice was twice that when competing with rice. Vegetative expansion of rhizomes and subsequent shoot production appears to be the main means of patch growth, which is expected to be much slower than that of annual weeds that mainly spread via seed dispersal. This research has provided answers for rice growers having problems controlling rice cutgrass. In the past, many rice herbicides were being applied with little success in controlling this weed. Growers will now be able to suppress rice cutgrass in conventional rice using bispyribac-sodium or completely control the weed in Clearfield rice using imazethapyr.

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## Glyphosate-resistant common ragweed

#### Issue

The discovery of glyphosate-resistant common ragweed in Arkansas created a need for determination of physiological resistance.

#### Action

Common ragweed (*Ambrosia artemisiifolia*) from Pope and Jackson County, Ark., was determined to be 21- and 10-fold more tolerant to glyphosate, respectively, than a known susceptible. Physiological studies to determine the difference between the glyphosate-resistant and susceptible common ragweed were conducted. Glyphosate absorption and translocation studies indicated no significant reduction in absorption or translocation between both biotypes of susceptible common ragweed. Shikimate accumulation was quantified after glyphosate application and there was no difference between the known susceptible and the two resistant populations at 3 days after treatment (DAT). However, by 5 DAT, shikimate accumulation in the two resistant populations was lower than the known susceptible. Data indicate that there are two glyphosate-resistant common ragweed populations in Arkansas and the resistance mechanism is not an insensitive target site or reduced glyphosate absorption or translocation.

#### Impact

The mechanism of resistance still needs to be determined through additional research.

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#### Funding

Arkansas Soybean Promotion Board  
Division of Agriculture, University of Arkansas

## Production and economic tradeoffs in early-maturity soybean

#### Issue

Early-maturing soybean production has a major impact on Arkansas agriculture.

#### Action

A two-year field study was conducted to determine the influence of soybean maturity group (MG), plant density, and herbicide program on soybean yield. The experimental design was a split-split plot. Main plots were MG II (AG 2203), MG III (S31-V3), and MG IV (AG 4801). Subplots were a factorial arrangement of planting density, 75,000, 125,000, and 200,000 seed/A, and herbicide program, which consisted of a conventional program and two RoundupReady® programs. The conventional program was S-metolachlor plus metribuzin applied preemergence at the recommended rates for soil texture, followed by fomesafen plus sethoxydim applied at 0.75 lb ae/A at the V3 and V6 stages and glyphosate applied at 0.375 lb/A at the V2 stage and again whenever control reached less than 80% on a particular treatment.

Regardless of MG, yield was greater at the 200,000 seed/A planting rate than at 125,000, and 75,000 seed/A. Herbicide program had no effect on soybean yield; however, the conventional program did not control entireleaf morningglory late into the season. The lack of adequate late-season morningglory control was more prevalent for the MG II soybean than the other varieties. Both RoundupReady® programs provided good control of both morningglory species (>90%), but the full-rate Roundup program did provide slightly higher control. Partial profit analysis indicated that planting soybean at 75,000 seed/acre in an early-maturing system was not profitable. The most profitable (partial profit of \$322/acre) production system was conventional MG IV soybean planted at a high seeding rate (200,000 seed/acre). However, the most consistent and economical treatments for high-yielding ultra-early soybean production would be MG III or IV soybean grown at 200,000 seed/acre with one of the RoundupReady® herbicide programs.

#### Impact

The weed management and economical analysis will improve the profitability of the early-maturity soybean production system.

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#### **Funding**

Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas

## **Effect of high temperatures during boll development on reproductive development and yield**

#### **Issue**

Although Arkansas cotton yields are the highest in the U.S. Cotton Belt outside of the arid West, they are still well below potential and suffer from unpredictability and year-to-year variability. Our preliminary studies have shown a strong correlation between high temperatures and low yields. However, little is known about the physiological response of cotton to high temperature and methods of quantifying the response. This information is necessary to be able to formulate strategies to counteract the deleterious effects of high temperature on growth and yield. The information is also needed to be able to screen the available cotton germplasm for high-temperature tolerance. The objectives of this study, therefore, were to evaluate and quantify the effects of mid-season, high day temperatures on physiological processes related to reproductive development and yield.

#### **Action**

Analysis of the long-term weather data for representative locations in Arkansas suggested that the upper temperature threshold was 95°F when yields started to decline significantly, and that night temperatures above 75°F had negative effects on yields. In subsequent growth-room studies, cotton plants (*Gossypium hirsutum* L.) were grown with day/night temperatures of 86/68°F (30/20°C), the reported ideal range for cotton, until peak flowering, at which time the maximum temperature was increased in 5°F increments up to 100°F for 3-day intervals. Measurements included photosynthesis, chlorophyll fluorescence, membrane leakage, antioxidant enzymes, leaf carbohydrate content, proteins, and leaf extension growth. Among all the techniques tested, fluorescence and membrane leakage were the most sensitive and practical techniques to quantify temperature tolerance in both controlled and field conditions. However, fluorescence appeared to be more reliable, whereas membrane leakage shows more variability. High temperatures had a strong negative effect on photosynthesis, but photosynthesis was not a practical technique to quantify temperature tolerance in large breeding trials. Antioxidant enzymatic activity increased significantly with elevated high temperatures, however, this technique was much too time-consuming. The studies also showed that at temperatures above 95°F (35°C), significant physiological changes occurred including decreased photosynthesis that would lead to reduced yields. This, therefore, represents an

upper temperature threshold value above which cotton growth and yields are likely to be negatively affected by elevated temperature.

#### **Impact**

Invariably, the cotton crop in Arkansas shows great potential mid-way through the season but, more often than not, fails to develop the high yield potential. Our studies have shown a strong correlation between high temperatures and low yields in Arkansas, and have also shown that high temperature is one of the main factors causing lower and more variable yields. At temperatures above 95°F, growth and yields are likely to be negatively impacted. These studies also documented that measurements of chlorophyll fluorescence and membrane leakage are sensitive and reliable techniques for assessing temperature stress that can be used for screening cotton germplasm lines for temperature tolerance. These results are being used to (a) screen the available cotton germplasm for temperature tolerance, and (b) formulate various strategies for ameliorating the adverse effects of high temperatures.

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#### **Funding**

Arkansas Cotton State Support Committee and Cotton Incorporated, Cary, N.C. Projects #04-440AR and #02-249-AR; Division of Agriculture, University of Arkansas

## **Establishing bermudagrass using improved seeded cultivars**

#### **Issue**

Common bermudagrass is a warm-season turfgrass species suitable for lawns, athletic fields, golf course tees, fairways, and roughs. Although bermudagrass seed has been available for many years, its use in high-value turfs has increased in recent years due to the release of new cultivars with improved turfgrass quality similar to hybrid bermudagrass. An advantage to seeded bermudagrasses is they can be established at a lower cost compared to sodding or sprigging. Some of these new, seeded cultivars have improved winter hardiness compared to hybrid bermudagrasses commonly used in Arkansas. Researchers have realized the need for studies on bermudagrass establishment from seed and several papers have recently been published on this topic including extensive work at the University of Arkansas. Despite the recent research completed on establishing bermudagrass from seed, the majority of information was not readily available to turfgrass practitioners.

#### **Action**

A review article was written and published in *Applied*



*Turfgrass Science* to provide a thorough overview of the procedures necessary to establish bermudagrass using seed. This review article contains information on choosing cultivars, site preparation, planting date, planting rate, weed control, fertilization, traffic tolerance, and establishment costs. This review article is currently being adapted into an extension publication for use by Arkansas turfgrass practitioners.

#### **Impact**

Establishing seeded bermudagrass will reduce establishment costs compared to traditional sprigging or sodding methods. Seed costs often start around \$5/lb for hulled or unhulled bermudagrass seed or seed that is coated. If seeded at a rate of 1.0 lb PLS/1000 ft<sup>2</sup>, then seed cost per acre is about \$242 using non-coated seed and \$519 or more for coated seed. By comparison, sprigging costs for bermudagrass start at \$1,000/A with sodding costs near \$7,500/A. Planting improved, winter-hardy bermudagrass cultivars will improve turfgrass quality, reduce reestablishment costs from winterkill, and ultimately increase sustainability.

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#### **Funding**

United States Golf Association; Golf Course Superintendents Association of America

## **Turfgrass evaluation program provides identified cultivars adapted to Arkansas**

#### **Issue**

Approximately 72% of the lawns in Arkansas are bermudagrass and 13% are zoysiagrass based on data submitted to the Arkansas Soil Test Laboratory in 2006. As a whole, bermudagrass and zoysiagrass have many positive attributes that make them successful turfgrass species, including good heat- and drought-tolerance, pest resistance, traffic tolerance, and tolerance to a wide range of soil types and water quality. However, specific cultivars of bermudagrass and zoysiagrass vary in their adaptation to climate, so it is important to evaluate them for their performance in Arkansas.

#### **Action**

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Department of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. Bermudagrass and zoysiagrass are tested on a 5-year cycle at sites throughout the transition zone and southern U.S. The University of Arkansas has been an active participant in the NTEP and has conducted several tests on bermudagrass and zoysiagrass cultivar adaptation since 1986. The 2002 bermudagrass and zoysiagrass NTEP tests ended in 2007 and a new 2007

bermudagrass NTEP test was planted in addition to planting an Arkansas zoysiagrass cultivar evaluation test in June 2007. Data collected in these experiments include turfgrass coverage, quality, genetic color, disease resistance, insect resistance, density, spring green-up, leaf texture (width), fall color retention, traffic tolerance, seedheads, seedling vigor, weed encroachment, drought tolerance, winterkill, and mowing quality.

#### **Impact**

Results from these studies are freely available to residents of Arkansas for making informed decisions when selecting turfgrass varieties. Planting well-adapted cultivars will improve turfgrass quality, reduce reestablishment costs from winterkill or drought, and ultimately increase sustainability. Data can be accessed at [www.ntep.org](http://www.ntep.org) or up-to-date information can also be found in Cooperative Extension Publication FSA2112, *Choosing a grass species for Arkansas lawns*.

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#### **Funding**

National Turfgrass Evaluation Program; Division of Agriculture, University of Arkansas

## **New markets for forest ecosystem services**

#### **Issue**

Forests provide a variety of ecosystem services to the public. Timber and wood fiber are the best known ecosystem services and have well-established markets. Landowners do not have markets to receive payments for ecosystem services such as clean air, water, and biological diversity that they provide to the public, even though they are often regulated and required to protect and provide these services. Two emerging ecosystem markets, one for carbon sequestration credits and the other for biomass production for biofuels, are developing in Arkansas. The objectives of this study were to assess the viability of these markets and develop mechanisms to assist landowners in accessing them.

#### **Action**

The cost and availability of forest biomass for biofuel production was assessed using data on Arkansas' forests supplied by the USDA Forest Service. Statewide, Arkansas is capable of producing between 4 and 5 million dry tons of biomass annually from logging residues. Supply analyses were conducted for 5 potential cellulosic ethanol sites in south Arkansas.

Access to carbon markets for forest landowners requires tools that allow them to inexpensively and accurately measure current biomass and carbon stocks on their forests and project future carbon stocks under any proposed manage-



ment scenario. A system for measuring inventory precision was developed for landowners and natural resource professionals, as well as methods for linking inventory data to public-domain growth models that are capable of projecting carbon sequestration as well as carbon stored in harvested wood products. Workshops and training materials were developed and are available to the public. Working with the Arkansas Forestry Commission, Farm Bureau, the Delta Institute, and the Chicago Climate Exchange, afforestation and working forest carbon-trading programs were established in Arkansas.

#### **Impact**

Logging residues could supply biomass sufficient to support 4-5 cellulosic ethanol plants, each producing 60-80 million gallons of ethanol annually. Direct payments to landowners for logging residues are not expected to yield income of more than \$5 million annually. However, the removal of logging slash will reduce reforestation costs and potentially save landowners as much as \$15 million annually. Fire, insect, and disease risks will be reduced by the harvest of logging residues.

At present, forest carbon markets will represent cash payments of less than \$2 million annually to Arkansas. However, it is likely that the United States will adopt a cap and trade system to limit CO<sub>2</sub> emissions in the near future, and the value of Arkansas' carbon markets could increase to \$25 million within 10 years.

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#### **Funding**

Division of Agriculture, University of Arkansas

### **Switchgrass issues for Arkansas agriculture: A 2007 baseline**

#### **Issue**

The need for biomass feedstock for renewable energy from agriculture has intensified with the recent passage of the 2007 Energy bill. Therefore, many agricultural producers are contemplating what crops to grow in the foreseeable future. On one hand are traditional food crops like soybean, corn, wheat, and rice that have recently enjoyed a spike in prices primarily due to the seemingly ever growing demands of the corn-to-ethanol industry. On the other hand are less-known perennial energy crops like switchgrass. While much information on various aspects of switchgrass production exists, some discussion on the adaptation of existing production and processing information to Arkansas conditions as a potential alternative to crop production was needed.

#### **Action**

The objectives of this study were to: i) document existing cost-of-production information for growing switchgrass in Arkansas along with some assumptions about likely and easily adoptable production methods; ii) utilize the cost-of-

production information to determine breakeven prices for producers and/or biorefineries under varying assumptions related to stand life; iii) conduct some sensitivity analyses regarding expected harvesting and transportation costs to biomass production facilities; and iv) discuss impediments and advantages for the adoption of switchgrass as an alternative crop in Arkansas.

#### **Impact**

The analysis revealed that prorated cost of production over the 12-year useful life led to a breakeven price of nearly \$25/dry ton of switchgrass stored at the edge of the field. Changing the useful life of the stand to 6 years, the breakeven price increased to nearly \$33/dry ton. Storage losses and transport charges added nearly \$12/dry ton to the above and producer payments for considering the crop added nearly \$18/dry ton. This information proved useful for highlighting the need for exploring additional storage, harvest, and transport techniques as well as providing a baseline for delivered feedstock costs to biorefineries. Expected future yield improvements and storage, harvest, and transport efficiencies would lower the above cost estimates, but competition for land resources may also raise producer payments required.

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#### **Funding**

Division of Agriculture, University of Arkansas

### **Digital image method developed to measure light interception in corn**

#### **Issue**

Light interception is an important determinant of maize yield, but light-interception measurements using a light bar can only be made when the sun is not obstructed by clouds, and measurements can only be made within an hour of solar noon.

#### **Action**

We modified a digital-image analysis system that we have used in soybean for use in maize. Our results show that this method agrees well with light-bar measurements, but precision is considerably higher with the digital-image method.

#### **Impact**

Digital-image analysis can be used using an inexpensive digital camera and off-the-shelf software. Measurements can be made any time of day and do not require unobstructed, direct-beam sunlight.

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Arkansas Corn and Grain Sorghum Promotion Board; Division of Agriculture, University of Arkansas

### Seven-leaflet soybean lines do not decrease required seeding rates

#### Issue

Early-maturing soybean varieties can have similar yields with considerably less irrigation than full-season varieties but require about twice the seeding density to have these high yields, which increases production costs.

#### Action

We developed soybean lines with 7 leaflets that were nearly identical genetically to the normal 3-leaflet lines to determine if more leaf area per plant would decrease the seeding rate needed for high yields. Our results indicate that the 7-leaflet genotype has about 20% greater leaf area per leaf but produces slightly fewer total leaves. The end result is that leaf area per plant and yield is similar in 7-leaflet and 3-leaflet isolines.

#### Impact

Short-season soybean production requires higher seeding densities than full-season soybean production and altering leaflet number does not affect this relationship.

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### Soybean gene for 7-leaflet trait is mapped

#### Issue

The gene that confers the 7-leaflet trait in soybean (lf2) has been mapped on the classical soybean map but not on the molecular soybean map.

#### Action

We created near-isogenic lines of soybean that segregated for the 7-leaflet and 3-leaflet trait. These lines were phenotyped for leaflet number, and molecular markers were used to associate chromosomal regions with the trait.

#### Impact

The lf2 gene has now been placed on the soybean molecular map and a linkage group of the classical soybean map can now be associated with the molecular map.

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### Soybean cyst nematode reaction to rotation of resistance reaction types

#### Issue

From the time soybean cyst nematode (SCN) infests a field, it will have to be dealt with as it cannot be eradicated. A major problem is that cysts can survive for many years in soil. Rotation of a SCN field into a non-host is one method of dealing with the infestation. This reduces the numbers of nematodes. Growing a resistant soybean variety is a second option. However, if a resistant variety or resistance type is used repeatedly, the nematodes will often overcome the resistance and then the variety behaves like a susceptible variety, with resulting yield loss and SCN increase. There are several types of SCN resistance reactions and what happens when these resistant types are rotated is the focus of these experiments.

#### Action

Two field experiments are testing the effects of rotating three SCN resistance reaction types: one with varieties derived from Peking, PI-88788, and Pi437654; the second from PI-88788, Cystex, and Pi437654. All rotation combinations of these resistance types are being studied, along with the effect of growing them successively. The theory is to determine if rotating resistance types will lower the SCN population to a non-damaging level where soybean is monocultured. We are entering the sixth year of the rotation in one field and the third in the second field. Because of the long-term survival of this nematode, more than one cycle is needed to validate this theory.

#### Impact

The SCN causes millions of dollars of loss each year in Arkansas. Soybean resistance to SCN is the most effective and economical control. There are several different resistant types, however, only a few types are used in resistant varieties at present and are derived from PI 88788, Peking, Cystex, and PI 437654. Monoculture of any of these resistant types will eventually allow the nematode to circumvent the resistance. At present over 95% of all SCN-resistant varieties are derived from PI 88788 and the resistance it instills is no longer effective in much of the soybean production acreage of Arkansas. We are testing rotation of the resistant sources PI 88788, Peking, and PI 437654 to test if nematode populations can be controlled and reduced by rotating these resistance types. If this rotation is effective, the need to rotate from soybean to a SCN non-host will be reduced or eliminated.

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### Funding

Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas; Other

## Influence of the soil texture on the interaction between *Meloidogyne incognita* and *Thielaviopsis basicola* on cotton

### Issue

Soilborne pathogens often limit the production of cotton. *Meloidogyne incognita*, the root-knot nematode, and *Thielaviopsis basicola*, the black root rot pathogen, are both important cotton pathogens that may interact synergistically, dramatically increasing disease losses in fields where both pathogens occur. The impact of soil texture on each pathogen and their interaction were studied because *T. basicola* is favored by soils low in percent sand and *M. incognita* by soils high in percent sand, suggesting the interaction may only occur in certain fields or portions of fields where the pathogens are present.

### Action

The impact of soil texture on *Meloidogyne incognita* (Mi), the root-knot nematode, and *Thielaviopsis basicola* (Tb), the black root rot pathogen, and their interaction were studied in microplots using a sandy loam soil and different artificial soil textures produced by mixing this soil with sand. The soils were pasteurized and six treatment were used: 1) noninfested, 2) Mi - 4 eggs/cc, 3) Mi - 8 eggs/cc, 4) Tb, 5) Mi - 4 eggs/cc and Tb, and 6) Mi - 8 eggs/cc and Tb. Plots were watered for each soil texture to limit differences in water among soil textures. Plant height, development, weight, and yield were reduced as sand content increased, especially in the sandiest soil. Plant height and growth were reduced early in the season by *T. basicola* and damage was less in the soils containing the greatest sand content. *M. incognita* also reduced plant growth and height and delayed fruiting. Height reduction was greater with *M. incognita* in soil that also contained *T. basicola*. Seedling disease and colonization by *T. basicola* decreased in the sandiest soil. The interaction between *T. basicola* and *M. incognita* resulted in lower galling and nematode reproduction. Over-winter populations of *M. incognita* were reduced by *T. basicola* in fine soil textures, and *M. incognita* survival was greater in sandy

soils. *T. basicola* reproduction and survival was greater in fine-textured soils. Soil texture had a greater impact on *T. basicola* than the root-knot nematode for these soil textures in this study where soil water content was controlled.

### Impact

The goal of this research is to determine the influence of soil texture on the interaction between *Meloidogyne incognita* and *Thielaviopsis basicola* on cotton. This will aid in predicting the impact this interaction will have in specific fields with these pathogens and the need for controlling either of the pathogens associated with the interaction.

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Arkansas Cotton State Support Committee; Division of Agriculture, University of Arkansas

## Use of seed treatments to improve soybean stand establishment and yield

### Issue

Soybean yield starts at planting with getting a strong, healthy stand. Seedling diseases not only reduce stand but can weaken the surviving seedlings, resulting in lower yields at the end of the season. To fight seedling diseases, growers use a variety of seed treatments, but these treatments vary in effectiveness depending on the type of soil, the planting date, and the pathogens that are attacking the seed and seedlings. Knowing which seed treatment to use and when to use it will improve yields and save growers money.

### Action

The most commonly available seed treatments, some with activity against specific pathogens and some with a broad spectrum of activity, were compared at three locations in Arkansas (Keiser, Stuttgart, and Hope) at three planting dates (April, May, and June). Stands were counted and yields taken. Seedling roots were assayed for the presence of seedling pathogens. In addition, soybean seeds were planted in soil from Stuttgart and Hope in growth chambers to compare stands and pathogen isolation from rotted seed and from seedlings.

### Impact

In general, seed treatments improved stands and yields at all locations and at all planting dates, although these improvements were not observed in every test. Improvements in stand and yield occurred most often in the April and June plantings when the seeds were stressed by either cold or heat, but were also seen in the May plantings. Seed treatments were more effective at Keiser and Hope. The broad-spectrum seed treatments, those affecting many different seedling pathogens, were the most effective, suggesting that seedling disease is not caused by a single type of pathogen, but by a complex. Isolation data from the field

showed that *Pythium* spp. were the most commonly isolated pathogens from soybean seedling roots. The species isolated depended on the temperature and soil moisture. Isolations from rotted seeds and from seedlings in the growth chamber tests showed that *Fusarium* spp. were the most common pathogens recovered from rotted seed while *Pythium* spp. were the most common isolated from seedling roots.

Our results show that seedling diseases can occur at any planting date but are most common when the seed and seedlings are under environmental stress. It appears that seedling diseases are caused by a complex of pathogens, in particular *Pythium* spp. and *Fusarium* spp., and that broad-spectrum seed treatments are the most effective. These results will be especially helpful as seed costs increase and Arkansas growers responded by reducing seeding rates.

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Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas

## An assessment of efforts to understand and develop recommendations for glyphosate-resistant weeds in Arkansas crops

#### Issue

In Arkansas, over 13 million gallons of glyphosate (the active ingredient in Roundup® herbicide) are applied each year. A large percentage of cotton, corn, and soybeans are RoundupReady© (tolerant to glyphosate). Widespread adoption of glyphosate-tolerant crops has allowed Arkansas farmers to increase conservation tillage programs and farm a larger number of acres with less equipment and labor. The number of farms with greater than 2,000 acres has increased by 30% since the adoption of glyphosate-tolerant crops. Most of our commonly used agricultural practices today are built around the use of this technology. Weeds that have developed resistance to the glyphosate herbicide now threaten our entire farming culture. Weeds now either confirmed or under investigation for glyphosate resistance in Arkansas include: common ragweed, giant ragweed, horseweed, johnsongrass, Palmer amaranth (pigweed), and ryegrass. While some of these weeds do not represent major threats to agricultural production practices, other such as Palmer amaranth do. In addition, due to the heavy selection pressure currently being applied on weed populations and the rate at which new resistant weeds have been discovered, it is only a matter of time until new glyphosate-resistant weeds are found.

#### Action

Multiple programs have been utilized to address the

problem of glyphosate-resistant weeds. Research efforts have focused on understanding the degree to which weeds can tolerate glyphosate. In addition, work has been conducted and is ongoing in learning the biology and heritability of the glyphosate-resistant traits. Numerous studies have been conducted to identify best management practices for herbicide-resistant weeds. In Extension, programs have focused on monitoring the spread of glyphosate-resistant weeds and increasing farmer awareness of this growing problem. Recommendations have been developed for known resistant weeds and these have been distributed through various media, publications, and the county agent system. Also, recommendations have been developed for major crops to try and curb the development of new weeds.

#### Impact

The University of Arkansas, Division of Agriculture has become recognized as a leader in resistance management. We have observed rapid adoption of the recommendations for controlling weeds known to be resistant in various crops. Greater than 80% of the farmers in a three-county area adopted our recommendations for controlling horseweed following our “Horseweed Wanted Dead, Not Alive” educational emphasis program. Recommendations include use of multiple herbicides in burn-down programs for horseweed in cotton and soybean, utilizing tillage and tank-mix options for common and giant ragweed in soybean, and the use of residual and post-applied tank-mix partners with glyphosate in cotton and soybean. In addition, through research efforts, Arkansas has now officially listed glyphosate-resistant common ragweed, giant ragweed, horseweed, and Palmer amaranth as being found in the state.

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## Measuring the rate that fissures form in milled rice kernels

#### Issue

Fissures can form in milled rice kernels during storage, transport, and conveyance. Fissures greatly weaken kernels such that during processing, dramatic losses can occur due to kernel breakage. Unacceptable fissure levels have been purported to be created due to transport and conveyance systems.



**Action**

A system was assembled to measure the rate at which fissures appeared in milled rice kernels when exposed to a range of environments. The system comprised a temperature (T) and relative humidity (RH) control chamber, inside of which was placed a rotating platform. Open Petri dishes holding samples were placed around the platform periphery. The platform rotation was controlled by a stepper motor and motion controller such that samples could be introduced to the viewing area of a camera. The camera was used to capture images of kernels with the aid of two fiber optic lights, which allowed fissures to be illuminated. Images were stored on a cassette recorder to allow fissures to subsequently be counted. Thirty milled rice kernels of cultivars Bengal, Wells, and CL161 cultivars at 11, 12, 13, or 14% MC were introduced to the camera viewing area every 4 minutes over a 24-h exposure duration. This procedure was conducted for 35 chamber air conditions, ranging from 5 to 30°C and 10 to 90% RH.

**Impact**

Kernel MC played a role in determining overall number of fissures formed; however the rate of fissure formation was practically similar across MCs. The medium-grain cultivar Bengal incurred more fissures than the long-grain cultivars, under given air conditions. The rate of fissuring increased with temperature, particularly at the low RH levels. Severe fissuring occurred at both low and high RHs; relatively little fissuring occurred in the 30 to 75% RH levels. At the lowest and highest RH air conditions, fissures formed very rapidly. For example, over 50% of kernels of all cultivars at all MCs had fissured within four minutes when milled rice was exposed to 30°C and 10% RH air. The results indicate that fissures can occur within minutes if milled rice is exposed to severe moisture-adsorbing or -desorbing environments. The kinetics information developed will allow damage assessment for current transport and conveyance systems as well as development of improved future systems.

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**Funding**

Kellogg Company; corporate sponsors of the UA Rice Processing Program; Division of Agriculture, University of Arkansas

## **Bermudagrass needs potassium to produce optimal yields**

**Issue**

Phytoremediation via intensive cropping with warm-season forages is one option for reducing high P levels of soils that have received large amounts of biosolids or manure. However, crops remove large amounts of potassium

(K), about 7 times more than P, making K fertilization an important consideration for forage production. Due to the high K removal rate, proper K fertilization is required to maintain soil productivity, maintain bermudagrass stands, prevent winter kill, and sustain high-yielding forages.

**Action**

Research was established to determine how bermudagrass K removal and yield are affected by K-fertilization rate across time. Beginning in 2006, K-fertilizer rates of 0 to 500 lb K<sub>2</sub>O/acre/year were applied annually in split applications to a soil with a *medium* soil-test K level. Forage was harvested three times in 2006 and four times in 2007 with yield and total K uptake and removal measured.

**Impact**

Bermudagrass yield was increased from 9-18% in 2006 and 51-69% in 2007 by application of 200 to 500 lb K<sub>2</sub>O/acre/year. Well-fertilized bermudagrass forage removes approximately 50 lb K<sub>2</sub>O/ton. In the absence of adequate K fertilization, bermudagrass yields decline dramatically and rapidly making sufficient K fertilization a requirement to sustain high forage yields. Failure to apply sufficient K fertilizer will reduce the uptake and removal of soil P and could eventually lead to stand loss and have a negative influence on the Arkansas beef cattle industry.

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**Funding**

Arkansas Soil Test Review Board/Fertilizer Tonnage Fees; Division of Agriculture, University of Arkansas

## **Soybean yields respond positively to poultry litter applied to silt loam soils in northeastern Arkansas**

**Issue**

Soybean grown on low cation exchange-capacity soils (sandy and silt loams) usually requires phosphorus (P) and potassium (K) fertilization to produce maximum yields. The prices of inorganic P and K fertilizers have gradually increased for the past several years and are expected to continue to increase as world demand and transportation/production costs increase. Natural resources produced within the state, such as poultry litter, may be cost-effective alternative P and K fertilizer sources for row crops and may offer other benefits that aid in sustaining long-term agricultural productivity to soils in northeastern Arkansas.

**Action**

Research was initiated at 10 sites between 2004 and 2007 to compare soybean response to equal P and K rates applied as inorganic P and K fertilizers or poultry litter. The

research objectives were to determine if soybean yields were stimulated by the application of an organic soil amendment above the response provided by standard fertilization and to evaluate the availability of P and K in litter. To satisfy these objectives, the P and K nutritional status of soybean receiving different fertilizer treatments was compared at the R2 growth stage and grain yield was measured at maturity.

#### **Impact**

Soybean yields were not benefited by inorganic fertilizer or poultry litter at six sites, but at four sites soybean receiving poultry litter produced significantly greater yields (10-18%) than soybean fertilized with equal rates of inorganic P and K fertilizers. Soybean at three of the four responsive sites did not respond to P and K fertilization, suggesting that another component of poultry litter may be stimulating soybean yields on some silt loam soils used for rice and soybean production. Considering the rising costs of inorganic fertilizer, the value of the P and K in poultry litter is economically attractive with litter having the added value of other micronutrients, nitrogen, and organic matter. Although the reason for increased yield of soybean fertilized with poultry litter is not currently known and the yield benefit does not appear to be consistent among soils, application of poultry litter based on soil and crop P requirements may aid in building the fertility status and productivity of soils in northeastern Arkansas and reducing micronutrient deficiencies in row crops.

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#### **Funding**

Natural Resources Conservation Service (NRCS); Arkansas Soybean Research Promotion Board; Arkansas Soil Test Review Board/Fertilizer Tonnage Fees; Division of Agriculture, University of Arkansas

## **Precise genetic engineering**

#### **Issue**

Transgenic crops have great potential for increasing agricultural productivity. The process of transgenic plant development is extremely inefficient because a large number of the transgenic candidates produced by conventional technologies become unstable.

#### **Action**

Researchers developed a novel technique called Recombinase-Mediated (RM) gene integration, which is designed to integrate a foreign gene into a predetermined locus in a precise single-copy pattern. Transgenic rice plants produced using this method displayed consistent and stable gene expression over successive generations.

#### **Impact**

Researchers plan to develop and evaluate this novel

technology that can be used to streamline the production of transgenic plants.

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#### **Funding**

USDA/ CSREES/ NRI; Division of Agriculture, University of Arkansas

## **Removal of unneeded DNA elements from transgene locus**

#### **Issue**

An ideal transgenic plant should contain a precise transgene locus and nothing else. However, for the identification and recovery of transgenic plants, it is necessary to co-introduce selection marker genes.

#### **Action**

Selection marker genes are dispensable after the recovery of a transgenic plant. Therefore, we are developing a strategy for removing these fragments from the transgene locus of rice. Further, we want to incorporate this feature in site-specific integration technology. Toward this, we have developed a strategy called "marker-free site-specific gene integration" that is based on the use of two different recombination systems. The first system, *Cre-lox*, is very well developed and studied. However, the second system, *FLP-FRT*, has not been developed for rice. Therefore, we are evaluating the utility of *FLP-FRT* system in the genomic manipulation of rice.

#### **Impact**

This project will lead to the development of a new recombination system that can be used for genetic manipulation of rice and implementation of a streamlined method for generating marker-free transgenic lines.

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#### **Funding**

USDA/ CSREES/ Biotechnology Risk Assessment

## **Unraveling molecular mechanisms of gene suppression for a broader understanding of plant response to environment, disease, and defense**

#### **Issue**

Genetic variability is an extremely important resource for developing new crop varieties. This resource can be further enriched by tapping into epigenetic variability. Epigenetic processes involve chromatin remodeling and play important roles in disease manifestation, defense process, and development. Additionally, the epigenetic processes are conserved in plants and animals.

### Action

Researchers performed molecular and genetic characterization of an epigenetic mutant of *Arabidopsis* phytochrome A gene.

### Impact

Understanding molecular mechanisms of gene suppression (or expression) may lead to the development of a technology for engineering epigenetic traits.

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Arkansas Biosciences Institute; Division of Agriculture, University of Arkansas

## Understanding outbreaks of forest insect pests

### Issue

In 2000, the Forest Service discovered tens of thousands of dead and dying red oaks in the forests of northern and western Arkansas. A significant cause of mortality in this “oak decline event” was an explosion of a previously innocuous, native wood-boring beetle, the red oak borer. Because of the likelihood of serious and long-term changes to forests from the death of the red oaks, ecologists, foresters, landowners, outdoorsmen, and environmentalists voiced their concern about the reasons for this outbreak.

### Action

Over the past six years, our team of students, technicians, and scientists felled and examined more than 240 oak trees from the Ozark and Ouachita National Forests. We investigated adult beetle emergence, flight behavior, host-tree selection, and factors affecting red oak borer populations and how they may influence borer and tree mortality. We’ve examined how trees respond to infestation and investigated the relationship of forest site, stand, and tree conditions to the distribution and abundance of the red oak borer outbreaks. We’ve developed a series of sampling techniques, specifically designed to estimate beetle densities within trees, within forest stands and across entire forests. We have extended our sampling to historical analysis of red oak borer populations over the past 70 or so years by new methods of tree ring analysis. We initiated GIS-based studies to visually define susceptible forests and forest conditions associated with increased red oak borers and tree mortality. This project has yielded five MS theses and four PhD dissertations, 20 published papers and more than 100 presentations.

### Impact

We know now that from 1940-1992, red oak borer was present at consistently low levels. The recent outbreak appears to have begun in 1994 and peaked in 2000-2002, with population levels more than 100 times higher than pre-outbreak. Populations declined in 2004 and are now nearly as low as before the outbreak. The present outbreak appears

to be over. Northern red oaks experienced the greatest mortality; that mortality was higher in dense stands on ridges than on slopes or in forests with lower densities of northern red oak. Red oak borer populations were also highest on ridges. We learned that adult red oak borers fly over a period of some 6 weeks from late June to early August in odd-numbered years only, and that adult beetles fly near the tree canopy rather than near the ground. We discovered that red oak chemical defenses against red oak borer are not different between healthy and unhealthy trees. When wounded, however, healthy trees recovered faster than unhealthy trees and thus may better tolerate invasion. We developed molecular techniques to identify red oak borer larvae (immature beetles have few distinguishing physical features).

We also developed molecular methods to survey for *Armillaria*, a root-rot fungus that may contribute to oak mortality, and determined that three species of this fungus are present in the Ozarks, the first confirmation of this fact. We do not yet know if that is significant in relation to tree mortality and the red oak borer outbreak. We confirmed that black carpenter ants eat red oak borer eggs and small larvae, and found them even when populations of red oak borer were very low. We are now determining whether carpenter ants are equally common in all trees and forest stands, or if their abundance is influenced by tree species or size, or site conditions such as controlled burns. We have developed GIS-based hazard models to help predict forest conditions that are most susceptible to red oak borer outbreaks in the future. We will provide a Web-based site at which forest managers and landowners can determine the level of hazard for their forest with regard to red oak borer outbreaks.

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USDA Forest Service; UA Center for Advanced Spatial Technology; UA Forestry Resources Center; and the Universities of Kansas, Missouri, California, and Illinois

### Funding

Division of Agriculture, University of Arkansas; USDA Forest Service

## Evaluation of a 3- and 5-day irrigation interval in a furrow-irrigated rice production system

### Issue

In Arkansas, rice production systems traditionally utilize flood-irrigation to meet water needs of growing rice plants and for weed management. Recently, interest in the feasibility of furrow-irrigated rice has gained interest among Arkansas rice producers. Furrow-irrigation is typically used for production of corn, cotton, and soybean in Arkansas. Furrow-irrigation offers the potential of irrigation-water savings throughout the growing season. The potential of

water savings is of great interest in Arkansas due to current water issues.

### Action

Cybonnet, a conventionally bred rice cultivar, and XL 723, a hybrid rice cultivar, were seeded at recommended rates into 38-inch raised beds. Both irrigation intervals were initiated when rice reached the four-leaf stage, which is when rice is typically flooded in a flood-irrigation rice production system. Research observations collected included rice plant heights, yield components, rough and milled rice yields, and effects on soil moisture.

### Impact

Rice yields following both furrow-irrigation intervals were less than those observed in a flood-irrigated system. No differences in rice yield were observed between the two irrigation intervals. Less irrigation water was used for both irrigation intervals compared to water typically used for flood-irrigated rice on a clay soil. In this research, pumped irrigation water savings may not have been able to offset the loss of rice yield in a furrow-irrigated rice production system, which could adversely affect Arkansas rice producers. Research into this topic is ongoing.

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### Funding

Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas

## Characterization and introgression of reniform nematode resistance from diploid cottons to upland cotton

### Issue

The reniform nematode (RN), *Rotylenchulus reniformis*, is a serious threat to cotton production. In fields infested with RN, yield losses are estimated at 340 to 452 kg/ha (Robinson, 2001). According to the Arkansas Nematode Diagnostic Clinic 2004 (Cooperative Extension Service, 2005), the RN is present in twelve counties in the state, where most of the cotton (*G. hirsutum*) is cultivated. Genetic resistance to RN has not been reported for any commercial cultivar (Robinson et al., 2004); however, it has been found in *G. arboreum* (Stewart and Robbins, 1994), but little is known about the resistance mechanism. The objectives of this study were to (a) develop reniform nematode-resistant lines in early backcross generations as germplasm source for cultivar development and, (b) describe the response of cotton roots at the transcriptome level in response to RN infection.

### Action

RN resistance introgression: A genetic bridge was used to transfer RN resistance from diploid *G. arboreum* (A2) to tetraploid cultivated cotton by hybridizing it with *G. trilobum* (D8) to produce an interspecific hybrid A2 x D8 that was treated with colchicine to double the chromosome complement. The resulting synthetic allotetraploid was backcrossed with *G. hirsutum* cv. DP491 as recurrent parent. Segregating backcrossed populations were selected for reniform nematode resistance by inoculating individual plants with 3,300 nematodes in 500-cc pots containing pasteurized sand and calculating the reproduction ratio ( $p_i/p_1$ ) dividing the final number of nematodes by the initial number inoculated after two months.

Two important results were obtained. First, the mean of the resistant source *G. arboreum* (A2-194) was not statistically different from the fallow control, which indicates that A2-194 conferred an excellent level of resistance by suppressing nematode reproduction. Second, the BC<sub>1</sub>F<sub>2</sub>, BC<sub>2</sub>, BC<sub>2</sub>F<sub>2</sub>, and BC<sub>3</sub> populations were segregating for resistance with the means being between A2-194 and DP491, the susceptible control. This confirmed that RN resistance was transferred into upland cotton

Gene expression: Cotton seeds from *G. arboreum* resistant (A2-194) and susceptible (A2-128) accessions were germinated and transplanted into 500-cc clay pots filled with pasteurized fine sand. Four treatments with 3 reps were applied to 1-month old plants: 1) Resistant-inoculated (RI); 2) Resistant non-inoculated (RNI); 3) Susceptible-Inoculated (SI); and 4) Susceptible non-inoculated (SNI). Inoculated treatments received 5,500 vermiform-stage nematodes per pot. After 16 days, total root RNA was extracted. AFLP markers were used to identify polymorphism between treatments. Selected polymorphic bands were cloned and sequenced to identify the transcripts.

Expression changes were classified according to their distribution between accession and inoculation. Cellular transport, cell cycle, and DNA processing resulted in more transcripts in the susceptible accession than in the resistant one. It is hypothesized that those processes may be related to *syncytia* formation. On the other hand, processes that may be involved in resistance mechanism such as cellular rescue, defense, and transcription had more transcripts in the resistant accession. Surprisingly, so far no gene-specific expression has been detected in the resistant accession when infected by reniform nematode, suggesting that resistance may be related to a down-regulated gene during nematode feeding, but additional supporting data need to be obtained before the validity of this statement is verified.

### Impact

The hybridization of reniform-resistant *G. arboreum* with cultivated cotton was successfully accomplished by crossing synthetic allotetraploid [2(A2-194 x D8)] with tetraploid upland cotton. In this way, RN resistance was transferred to *G. hirsutum* at early backcross generations. These populations will be used in breeding programs to develop RN-resistant cultivars. They are also valuable to



increase genetic diversity in cotton as a source of other potential traits of interest derived from *G. arboreum* and *G. trilobum*.

Unveiling the RN resistance mechanism found in *G. arboreum* can be used as a tool for the potential development of rational strategies for nematode control such as rotation and pyramiding resistance genes with different mechanisms in order to delay the appearance of nematodes that overcome host resistance. Alternatively, in the absence of markers linked to resistant genes, differentially expressed genes can be used to select for resistance in developing populations. Finally, putative genes involved in *syncytia* formation can be the targets for gene silencing to induce resistance.

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Delta & Pine Land Co.; Division of Agriculture, University of Arkansas Agricultural Experiment Station

## Effect of antifungal peptides on mycorrhizal associations

#### Issue

Mycorrhizal associations are extremely beneficial, and in some cases essential, to plant growth, including cotton. Mycorrhizal associations are composed of a fungus that will grow intercellularly within a plant root and draw carbohydrate from the plant without causing a pathogenic response. In return the fungus extends its hyphae into the soil to take up minerals and water, which the plant uses. A plant root in a mycorrhizal association can explore a much greater volume of soil than a root without such an association. Many fungi are pathogenic and can cause significant economic damage to the plant. Many antifungal peptides have been discovered and generally these are effective in helping plants defeat pathogenic fungi. Since mycorrhizal associations also involve a fungus, there is the possibility that antifungal peptides may negatively impact the non-target beneficial mycorrhizal associations as well as aid in plant resistance to pathogenic fungi.

#### Action

Compared to wild type tobacco plants, two transgenic antifungal peptide genes expressed in tobacco seedlings were tested for their influence on the formation of mycorrhizal associations in tobacco plants using *Glomus mosseae* and *Gigasora rosea* as the test mycorrhizal organisms. (Tobacco was used because transgenic plants can be obtained quickly, and tobacco supports mycorrhizal associations.) In addition, R1 tobacco seedlings genetically engineered and expressing a bacterial chitosanase were included and evaluated for the ability to form mycorrhizal associations compared to the wild-type genotype.

#### Impact

The two antifungal peptides did not negatively influence the formation of mycorrhizal associations. Also, constitutive expression of the *Paenbacillus* chitosanase did not interfere with the levels of root colonization by AM fungi. The results will provide information to regulatory agencies concerning the effect of transgenic plants expressing anti-microbial peptides on mycorrhizal associations and potentially on other microorganisms in the plant rhizosphere. It should be noted, however, that the antifungal peptides were sequestered in the chloroplasts and cytoplasm of the tobacco plants. The influence of the peptides on the fungi should be determined when the peptides are targeted to the cell exterior where the fungi grow.

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Cotton Incorporated; Division of Agriculture, University of Arkansas Agricultural Experiment Station

## Evaluation of a red anther trait of *Gossypium armourianum* introgressed into *Gossypium hirsutum*

#### Issue

The flower buds of cotton are susceptible to the attack of many insects such as the cotton weevil, the bollworm species, and species of the Miridae family. Even though insect-resistant transgenes are being developed (cotton expressing Bt transgene has already been developed providing resistance against the bollworm species), there is also a necessity of targeting their expression to the tissues or cells where these pests are feeding. Thus, any secondary effect caused by the transgene would be avoided and reduce the energy cost of its expression while still providing resistance to the pests. This can be done by using tissue-specific promoters upstream of the transgene sequence. In this research we studied and attempted to identify the gene that activates red pigment production (anthocyanins) specifically in anther-wall cells from *Gossypium armourianum*, a wild new-world diploid species related to cotton. If identified, the promoter of this gene could be used to target the expression of a transgene to the anther-wall cells, thus providing resistance to anther-feeding insects.

#### Action

The red anther (RA) trait was introgressed into upland cotton from its D-genome diploid relative *G. armourianum* (D2-1) by crossing this species with an A-genome diploid *G. arboreum* and treating the hybrid with colchicine to make a synthetic allotetraploid compatible with upland cotton. After several cycles of self-pollination and backcrosses to upland cotton, a segregating population of the RA trait was obtained and used in this research. RNA was extracted from

white and red anthers and converted to cDNA by reverse transcription in order to determine which gene is being up-regulated in the red anthers. PCR primers for the genes in the pathway leading to anthocyanins production were designed.

#### Impact

All of the genes leading to anthocyanin production seem to be expressed in both the red and the white anthers. The explanation of this could be either that RNA was extracted from whole anthers (not just from cells producing anthocyanin), or that there are branches from the pathway leading to other secondary metabolites (flavonols, condensed tannins, etc.) that could be produced in anther cells. In order to analyze specifically the anther-wall cells, we developed a method to separate anthers into single cells using a pectinase treatment and flow cytometry. Thus, it should be easier now to see the differences between white and red anther-wall cells in the expression of the genes from the flavonoid pathway leading to anthocyanin production.

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## Molecular diversity and association analysis of agronomic characteristics in *Gossypium arboreum* L. cultivars

#### Issue

Cotton (*Gossypium* L.) is the leading fiber crop in the world. The narrow genetic base of the primary cotton (*G. hirsutum*) breeding gene pool is one of the major constraints in breeding programs worldwide. This underscores the necessity of enriching the gene pool with genetic diversity. *Gossypium arboreum* possesses many favorable traits for cotton production that the tetraploid cultivars lack, which makes it a genetic resource for tetraploid cotton improvement; however, it has not been well characterized at the molecular level. Understanding the genetic relationships within *G. arboreum* would facilitate efficient use of this resource for developing superior cotton cultivars with favorable agronomic traits.

#### Action

A population of 96 *G. arboreum* cultivars from 11 regions of Africa, Asia, and Europe was used for assessing genetic diversity and association mapping. The accessions were primarily cultivated varieties and are included in the USDA-ARS National Plant Germplasm System. The microsatellite primer pairs that we used were 50 genomic pairs that were developed at the Brookhaven National Lab and 65 EST-SSRs primer pairs that were provided by USDA-ARS in Shafter, Calif. The agronomic characteristics that

were analyzed for potential associations with molecular markers were 8 fiber traits (lint %, lint color, elongation, micronaire, 50% span length, 2.5% span length, and maturity) and 6 morphological traits (leaf shape, petal color, petal spot, petal spot color, leaf color, and pollen color) taken from field plants grown at Fayetteville, Ark., in the years 1989 through 1991. The accessions were also grown at College Station, Texas, in 1991 for verification of observations. All computations were carried out with appropriate procedures of the software packages NTSys 2.1, Structure, Arlequin 3.1, TASSEL 1.9.4, and Jump 5.1.

#### Impact

Molecular markers that reveal DNA polymorphisms have proven to be a powerful tool for genotyping and estimating genetic diversity. Among molecular markers, SSR markers efficiently and effectively reveal the genetic diversity of crop germplasm collections. We proposed a set of SSR markers for use in  $A_2$  species diversity studies. The loci were selected based both upon their high level of informativeness ( $PIC \geq 0.50$ ) and the production of distinct bands in the electrophoresis gels. The set of twenty-five SSRs is sufficient for studies of genetic diversity of *G. arboreum* accessions. Also, identifying a genotyping set of highly polymorphic microsatellite markers is expected to increase the efficiency of genetic diversity assessment and variety identification. A systematic genetic assessment of the gene resources will help to decrease redundancy and to construct a core germplasm collection, which is important for efficient use of these genetic resources in cotton breeding.

Tests for associations between the 115 markers revealed significant associations between cotton fiber and morphological traits and SSRs in *G. arboreum* germplasm. This study demonstrated that association analysis in diploid cotton germplasm can enhance the information from QTL studies toward the implementation of marker-assisted selection. Genetic association mapping has greater power than linkage studies to identify variants with weak effects that might contribute risk for common complex traits. Whole-genome association studies have the advantage of enabling the entire genome to be assessed for trait-associated variants, rather than analyzing specific candidate genes. Application of association mapping to plant breeding seems to be a promising means of overcoming the limitations of conventional linkage mapping. The positive results from this study should encourage the further testing of these methods in different genetic systems, in the same way as we applied these procedures to cotton.

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## Diseases of grain sorghum

### Issue

Arkansas continues to rank high in the U.S. in the annual production of grain sorghum grain. From 1997 through 2000, approximately 136,500 acres of grain sorghum were harvested in Arkansas each year. In 2003, the total estimated value of grain sorghum was \$40,309,000. Grain sorghum also has intrinsic value as a crop as harvested grain and as a rotation with other crops to help producers control weeds, insects, and plant diseases. However, yields per acre in the state have remained relatively low compared to other regions. Many plant diseases affect grain sorghum yields, reducing both yield and grain quality and in some areas of the state, yield losses due to diseases may range from 10-50% each year. Anthracnose, caused by a fungus *C. sublineolum*, is the most important disease of grain sorghum in the state, and we have routinely been called out to investigate or found instances of crop failure due to this disease each year.

### Action

To develop the most comprehensive management strategies and techniques available and to correct for the lack of information on grain sorghum pathology in Arkansas, selected hybrids and experimental breeding lines of grain sorghum were evaluated on four of the UA Experiment Stations within the Delta region. We also examined the population of sorghum anthracnose in the state to find out why so many different hybrids were being infected by this devastating fungus.

### Impact

Information concerning the best management practices for production of grain sorghum is proving to be useful by providing reliable information to growers about the hybrids and practices that minimize the importance of diseases while increasing their yields and profit. We can now suggest simple rotations and careful selection of hybrids as effective ways to reduce the significance of diseases on grain sorghum in production. We have also found and identified extremely virulent races of the anthracnose fungus that have never been described in the literature and discovered that these not only infected all known hybrids but were responsible for the outbreaks in Arkansas that were being reported each year.

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### Funding

Division of Agriculture, University of Arkansas Agricultural Experiment Station; Arkansas Corn and Grain Sorghum Promotion Board

## False smut of rice

### Issue

Arkansas ranks first in the U.S. for rice production. In 2003, 1.4 million acres were harvested for a total value of over \$740 million. Plant diseases are critical actors in achieving and maintaining high seed quality and levels of productivity. In 1997, a disease called false smut, caused by a fungus, was found in Arkansas for the first time. Though widely known in other parts of the world, little information is available to describe how the disease is dispersed from one location to another or how the fungus is able to infect rice plants. Additionally, little is known about how resistant our rice cultivars are to infection by the fungus although many, if not all, appear to be highly susceptible. In other parts of the world, this disease has already become very serious, reducing yields by as much as 50%; a potential loss of millions of dollars to Arkansas. The overall objectives of our research were to determine how the fungus initiates infection of plants and how the pathogen survives to cause disease each year.

### Action

We inoculated roots, soil, and foliage with spores of the fungus and examined their behavior on tissues. We found that the fungus infected roots directly from infested seeds and from soils. We also used PCR to 'track' the fungus within plants and found that the fungus was in all parts of the plants even when inoculated from soil. PCR is an extremely useful tool to measure how this fungus invades plants. We also found a new potential tool to help control this disease because we found that a fungicide, used in a similar situation on another crop, effectively reduced infection of rice by false smut.

### Impact

Our PCR results clearly show for the very first time that the fungus is seed-transmitted and that the fungus infects plants in many ways, including from spores in soil, without producing symptoms. Furthermore, infection has resulted in blanking of panicles produced by infected plants. The impact of our work is that we now know and understand how rice is infected by this fungus and these facts permit us to develop more effective means in managing the dispersal and importance of an emerging disease of rice in Arkansas. The results may also influence how producers growing rice for commercial distribution as seeds may protect and enhance the value of their product.

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Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas Agricultural Experiment Station

## Arkansas Global Rice Project provides Farm Bill policy and market analysis

### Issue

The U.S. rice industry is an important field crop that provides both domestic and international markets supplies of high-quality rice. Arkansas is the leading rice-producing state, where 1.3 million acres are planted to rice. Arkansas rice producers are particularly vulnerable to instability in domestic and international rice prices and costs of production. In a number of recent years, Arkansas rice producers have depended heavily upon the price and income supports of the U.S. federal government to provide income and market stability. The formulation of the 2007 Farm Bill has the potential for reduction in support levels in response to federal deficits, WTO dispute rulings, and Doha round proposals. Federal price and income support is important to maintaining the safety net for rice producers. Rice is the most trade-distorted crop exported by the U.S. due to protectionist policies by many Asian and European countries who protect their producers and consumers to achieve food security objectives. The rice market is particularly unstable because it is subject to 1) the Asian monsoon weather, 2) high levels of trade protection, and 3) a high degree of market segmentation based on product differentiation at the production, processing, and consumption levels. Market participants and policy decision makers need market and policy analysis on a regularly updated basis to understand changes that influence prices, production, and consumption patterns.

### Action

The Arkansas Global Rice Project has developed a team approach to monitoring and analyzing market and policy events in the global rice economy. Baseline 10-year projections of the major rice-producing, -consuming and -trading nations are developed on the basis of a supply and demand simulation model, AGRM (Arkansas Global Rice Model). This framework provides estimates of production, consumption, trade, prices, and stocks based on historical supply and demand relationships, policies, and macroeconomic variables such as population and income growth. The model and results are presented at our Web site:

[http://www.uark.edu/campus\\_resources/ricerssch/](http://www.uark.edu/campus_resources/ricerssch/)

A spatial equilibrium model, RICEFLOW, which estimates country-to-country differentiated rice trade flows by rice type and degree of milling is also maintained. This model is particularly useful to evaluate regional trade agreements and transportation and other transaction cost impacts. Another important element is developing the ability to analyze representative Arkansas rice and cotton farms for changes in policy, technology, and market conditions. Farm-level analysis provides an important perspective that policy decision makers and the rice industry need to make sound decisions. Research on the 2007 Farm Bill has focused on the impacts of alternative bills and amendments put forth in the drafting of the legislation. As the 2002 Farm Bill legislation expired in 2007, studies are being conducted to investigate alternative proposals for the 2007 Farm Bill.

More recently, the rice research has also used a computable general equilibrium CGE model of the global rice economy using the GTAP framework, maintained at Purdue University, to capture impacts of policy changes not only on the rice product market but also related commodity market and input-factor markets such as labor and capital.

### Impact

The research on the Arkansas, U.S., and global rice economy and analysis of farm bill proposals and trade protection received considerable attention in 2007 from the World Bank, the United Nations, the U.S. Congress and many policy and industry decision-makers in the U.S. and the rest of the world. Numerous presentations were made in 2007 to present the prospects of farm bill impacts and impact of trade liberalization and challenges facing the U.S. and global rice economies. Domestic and international players (USDA, ERS and FAFRI, Iowa State University and University of Missouri, the World Bank, OECD, FAO, and the Government of Japan) have requested assistance from the Arkansas Global Rice Economics team in developing their rice market analysis. The model is being used to assess the impact of the U.S. proposal to WTO Doha Round trade negotiations. A commissioned paper for the World Bank, assessing multilateral trade reform in rice trade, was also prepared. An analysis of the impact of the Japanese rice tariffication was prepared for both the U.S. and Japanese rice industries and governments. Our analysis is unique due to its recognition of both long- and medium-grain rice markets, which no other research group includes. It is unique because we are not constrained to use *official* government data or policies in our analysis and therefore maintain a greater degree of objectivity. The beneficial outcomes of our models include better production, processing, and consumption decisions by market participants and better policy decision-making by the U.S. and foreign governments. Research on the 2007 Farm Bill proposals provided policy decision makers information on farm-level impacts of proposed changes that if adopted would have been disastrous for Arkansas rice and cotton producers.

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## Evaluation of the economic benefits and costs of zero-grade rice

### Issue

The majority of rice acres in Arkansas are flood irrigated using contour levee systems. Contour levee rice fields require large amounts of applied water to maintain a flood



during the production season. Fields precision-leveled to a zero-grade require significantly less applied water and provide significant savings in production costs relative to contour levee fields. However, zero-grade is a land improvement and requires a large initial capital investment, and much time may pass before economic benefits are received. The rotation chosen for the field after zero-grading also impacts the monetary benefit and the length of the investment's payoff period. This study uses a net present value (NPV) approach to evaluate the monetary benefits and pay-off period of zero-grade management in rice production for different rotations.

### **Action**

Precision leveling expenses were calculated based on phone conversations with farmers, land-leveling professionals, and equipment dealers in Arkansas during 2006. Expense estimates were calculated for single and dual pan equipment and included fuel, labor, repair and maintenance, depreciation, and interest charges. All precision-leveling expenses were calculated for varying volumes of soil moved per acre assuming 200 acres of land were precision-leveled per year. Monetary benefits to zero-grade were defined as the difference in per-acre net returns between zero-grade and contour-levee management. Present values of monetary benefits to zero-grade were calculated for alternative planning horizons (years), assuming a typical rice-soybean rotation for contour-levee management and either a three-year rice-rice-soybean rotation or a continuous rice rotation for zero-grade management and a discount rate of 7.75 percent. The NPV for each planning horizon was calculated as the sum of present values to zero-grade management less the initial per-acre cost of precision leveling to a zero grade. The payoff period was determined as the end year in the planning horizon for which the NPV was greater than or equal to zero.

### **Impact**

The results indicate that the amount of soil moved per acre greatly impacts the profitability of zero-grade management. The per-acre initial cost of precision leveling to a zero grade increases as the amount of soil moved per acre increases, and the amount of soil moved may be too excessive to allow the practice to be profitable for every field situation in the long run. However, the results imply that greater cost efficiencies may be achieved for large volumes of soil moved using dual rather than single pan equipment. The results also indicate that the rotation chosen after precision leveling to a zero-grade strongly impacts the monetary benefits and the pay-off period associated with zero-grade management. Net present values were larger and payoff periods were shorter for zero-grade when rice was grown continuously rather than rotated with soybeans following the land improvement.

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Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas



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# A Healthy, Well-Nourished Population

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## Eating behavior interventions and the obesity epidemic

### Issue

Overweight and obesity have reached epidemic proportions in the United States. Recent reports indicate that Arkansas ranks seventh in incidence of obesity with more than 63% of adults and 37% of school-aged children being overweight or obese. Young females are reported to have more negative perceptions of body image than do young males. These negative perceptions are beginning at a younger age. Because obesity is a major health problem that frequently begins in childhood and adolescence, it is important to determine and provide interventions to prevent inappropriate eating behaviors. A longitudinal study has been designed to gather anthropometric and survey data to: (1) correlate body mass index (BMI), percent body mass index, and body image with obesity in pre- and post-pubescent females in rural Arkansas communities; (2) determine if BMI is the most appropriate tool for evaluating weight status in growing children and young adolescents; (3) determine if a low BMI is an indicator of appropriate lifestyle and eating behavior; (4) determine if a high BMI is an indicator of inappropriate lifestyle and eating behaviors; (5) determine if young girls' perceptions of their body type or image changes as they go through puberty; (6) determine if changes in body perception can be a predictor of inappropriate eating behaviors; and (7) determine the differences in BMI, body fat, and body image in ethnically diverse populations living in rural communities.

### Action

An apparel studies and human nutrition research team completed a pilot study to methodology in December 2007. Over 200 college-age students participated in the study. Body measurements were taken using the [TC]<sup>2</sup> NX<sub>12</sub> Body Measurement System. Body composition and BMI were measured using bioelectrical impedance analysis. A questionnaire was administered to evaluate body image perceptions. Data analysis is in progress. Preliminary data suggest that female students are more negative about their body image and give a greater importance to body image than males.

### Impact

Knowledge gained from these studies will find direct application in eating behavior interventions. Interventions can be designed for maximum effectiveness through studying an ethnically diverse population.

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## Evaluation of dietary supplement safety

### Issue

The use of dietary supplements is popular in the United States. These products include a wide variety of natural products such as botanicals and the traditional vitamin and mineral nutrients. Many of the botanical dietary supplements are also used worldwide as part of traditional or folk medicine. Dietary supplements are used to both enhance the nutrient content of the diet and for their pharmacological effects. Current dietary supplement regulations in the United States may, in certain circumstances, place consumers at risk. Likewise, the use of the products as part of folk medicine has been associated with adverse events in developing countries. Therefore, it is necessary to evaluate the safety of these products in order to allow consumers and healthcare providers enough information to make informed decisions regarding their use. The majority of adverse events associated with dietary supplement use are associated with products that are contaminated or used inappropriately. These issues can be reduced or eliminated by a proactive and ongoing evaluation of dietary supplement safety.

### Action

Proper evaluation of dietary supplement safety requires laboratory research, human clinical trials, and consumer education. All of these areas were addressed. The botanicals chamomile and echinacea were evaluated for their potential contamination. Herbal preparations from Kenya that are used by HIV-positive patients have also received microbiological testing. Dietary-supplement whey-protein products, popular with athletes, were evaluated. Consumer and professional educational materials were prepared regarding the potential of these products to interfere with standard pharmaceutical products and medical procedures and the results presented at meetings in South Africa and at The American Dietetic Association and the Arkansas Dietetic Association.

### Impact

Evaluating dietary supplement safety has been a direct benefit to consumers and the dietary supplement industry. Results from this work have been incorporated into training materials for medical professionals. Also, as a result of the research, product changes were made to product formulations. Continued work will allow information regarding the safety of dietary supplements to be used by governmental regulators to develop and enforce appropriate standards for the manufacture, sale, and use of these products. Consumers will continue to use dietary supplements as adjuncts to medical care as long as confidence in these products is maintained.

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National Center for Toxicological Research

**Funding**

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## **Regulation of antioxidants in tomato by the jasmonate pathway**

**Issue**

Tomato products are the primary source of lycopene in the human diet, as well as a source of other antioxidants such as  $\beta$ -carotene and ascorbic acid. These antioxidants have been implicated in reducing the risk of cancer and heart disease, and may also reduce the degenerative effects of aging, such as neuronal cell death and memory loss. Furthermore, antioxidants from tomato are also extremely important early in life. For example, the carotenoid  $\beta$ -carotene is a precursor for vitamin A synthesis. Vitamin A deficiency is the most common form of malnutrition in children worldwide, and is a leading cause of blindness and death in children. Therefore, increasing the content of lycopene,  $\beta$ -carotene, and other antioxidants in common foods is a top priority for crop biotechnology and human health.

**Action**

We have investigated the mechanisms that regulate the accumulation of lycopene and other antioxidants in tomato in order to facilitate the development of foods with improved antioxidant content.

**Impact**

We established that a mutant tomato line that is deficient in synthesis of the plant hormone jasmonic acid (JA) has reduced lycopene content in comparison to nearly isogenic wild-type plants. This suggests that JA, which is responsive to UV exposure, insect damage, and a variety of other biotic and abiotic stresses, plays a role in regulating antioxidant accumulation in fruits. Furthermore, we found that exogenous application of JA to immature, wild-type tomato fruit resulted in increased total antioxidant capacity at ripening, as well as increased concentrations of lycopene. These results suggest that the nutritional quality of fruits could potentially be enhanced through artificial manipulation of the JA signaling pathway.

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Arkansas Biosciences Institute; Division of Agriculture, University of Arkansas

## **Anti-cancer peptides from heat-stabilized de-fatted rice bran**

**Issue**

Age-related chronic diseases becoming an important health and economic problem, complemented with less affordable therapeutic regimens, have brought forward the need for natural and alternative medicine. There is an increasing commercial interest in the production of economical bioactive peptides from proteins for nutraceutical potential. Anti-hypertensive, anti-cancerous, anti-mitogenic, anti-microbial proteins/peptides have been identified mostly in soy bean and milk proteins. Some examples are Lactotripeptide, soybean peptides, human recombinant lactoferrin, and casein peptic hydrolysate. Our goal was to produce peptides from a naturally cheap and nutritious food source that can arrest or help reduce the risk of cancer progression. Rice bran is a co-product of rough rice milling; although produced in abundant quantities in the U.S., it is only used as a low-cost animal feed. It contains 90% of the nutrients and nutraceuticals, including high-quality protein, phenolics, dietary fiber, vitamins, and minerals, in the grain. Commercially, rice bran is stabilized by heat treatment to prevent deterioration resulting from hydrolysis and oxidation of oil. The commercial rice bran after heat treatment and removal of oil (heat-stabilized defatted rice bran—HDRB—contains 18-20% protein) and at a cost of \$0.02 - 0.03/lb is mainly used for animal feed. Therefore, HDRB is an abundant and inexpensive source for the production of bioactive peptides.

**Action**

Arkansas researchers subjected commercial HDRB to endoproteolytic catalysis and produced protein fragments (peptides) with varying molecular sizes. For efficient absorption into the human system, gastrointestinal-resistant peptides were obtained after treating the protein peptides through simulated gastric and intestinal juices. The gastrointestinal-resistant peptides (GIRP) were fractionated into >50kDa, 50-10kDa, 10-5kDa, and <5kDa fractions. The fractions were tested for anti-cancer activities on human colon and liver cancer cells.

**Impact**

Peptide fractions <5kDa inhibited the proliferation of human colon and liver cancer cells better than a known anti-cancer agent, genistein. Demonstrating and characterizing bioactive peptides as anti-cancer agents, if needed, can promote commercial production of rice bran peptides by synthesizing in vitro. These GIRP, when incorporated into suitable food products, can provide anti-cancer effects. Separation and purification of anti-cancer-activity peptides are in progress. Amino acid sequencing of the most active peptide can lead to synthesizing these peptides in vitro for pharmaceutical use.



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CEMB Program and IFSE Matching funds; Division of  
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## Polyphenolic compounds in fruit

### Issue

Blackberries, black raspberries, and blueberries are rich in polyphenolic compounds such as flavonols (in all berries), ellagitannins (in blackberries and black raspberries), and procyanidins (in blueberries). These compounds are thought to play an important role in the prevention of chronic diseases including heart disease, stroke, several types of cancer, and various neurological disorders. The polyphenolic compounds in fresh berry fruit, which are available throughout the summer, have been well characterized. However, due to their delicate nature and limited shelf-life, berries are often preserved by freezing, baking, canning, juicing, and pureeing prior to consumption. Unfortunately, there is little information available on how different processing and storage methods influence the retention of polyphenolics. This information is needed in order to determine the potential health benefits of processed berries.

### Action

Fresh blackberries, blueberries, and black raspberries were evaluated as fresh, canned-in-water, canned-in-syrup (40° brix), puree (18° brix), and clarified and non-clarified juices. Samples were analyzed 1 day, and 1, 3, and 6 months after processing for total flavonol, ellagitannin, and procyanidin content. Juice processing resulted in extensive losses of ellagitannins and procyanidins in all berries due to physical removal of the seeds during juice pressing. Appreciable levels of the compounds were retained in the presscake after pressing and sediment after clarification. Thermal processing (canning and pureeing) treatments generally resulted in less than 20% losses of flavonols (all berries) and ellagitannins (blackberries and black raspberries), but processing of blueberry puree resulted in a 45% loss in procyanidins. Flavonols (all berries) and ellagitannins (blackberries and black raspberries) were well retained in canned and pureed products during 6-mo storage at 21°C, but significant quantities of the polyphenolics diffused from the berries to syrup in canned berries. Extensive losses of procyanidins occurred in all processed blueberry products (juices, canned, pureed) during 6-mo storage.

### Impact

Methods are needed to prevent polyphenolic losses during processing and storage, especially in juices where appreciable levels of the compounds are retained in waste materials. Future studies should focus on the development of methods to recover polyphenolics from waste materials. The recovered compounds could be added back to juices or be used as nutraceutical ingredients. In canned products, significant quantities of polyphenolics diffused out of the berries

into the liquid canning medium, indicating that methods are needed to prevent or ameliorate leaching of polyphenolics. Our results indicate that processed berries generally have lower levels of polyphenolics and antioxidant capacity than fresh fruit, but the processed berries are still a good, readily available source of antioxidants.

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Division of Agriculture, University of Arkansas

## Managing disease-vectoring mosquitoes in Arkansas using novel methods

### Issue

Rice is a major worldwide staple and mosquitoes generated in ricelands account for a high proportion of the world's vector-borne diseases. Malaria kills approximately 2.5 million people annually worldwide. Arkansas was once plagued by malaria, which is still potentially a threat. Other mosquito-borne diseases, such as West Nile virus, are constant threats. Arkansas rice lands are annually infested by hordes of mosquitoes. The movement of adult mosquitoes from rice fields to nearby urban communities is a major concern, particularly with regard to diseases. A need exists for new and improved management methods for mosquitoes associated with rice fields.

### Action

Investigation of new and promising larvicides will continue. The use of monomolecular film added to known larvicides was explored to ascertain whether efficacy and/or residual effectiveness were enhanced. Perimeter barrier treatments of permethrin in riceland mosquito resting habitats were assessed. Mosquito adults rest in vegetation in rice fields and surrounding farmlands and woodlands. Suitable locations in these habitats were selected for experimental plots treated with residual applications of permethrin. Mosquitoes were monitored by CO<sub>2</sub> traps.

### Impact

Source reduction and insecticidal treatment of mosquito breeding sites is often impractical, as is area-wide control of adult mosquitoes. Little, if any, attention has been directed to the use of perimeter application of residual insecticides to reduce vector infiltration by passive exposure to treated vegetation. The judicious use of pesticides at lower rates and thresholds offers the promise of more effective economical and environmentally compatible programs. Measured impact is difficult to ascertain. Improved quality of life and reduced threat of disease are obvious benefits.

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**Funding**

Regional Project S-1029, Improved methods to combat mosquitoes and crop pests in ricefields; USDA-ARS grant 58-6615-5-248; industry grant-in-aid funds; Division of Agriculture, University of Arkansas

## **Utilization of protein byproducts from poultry and other sources of inexpensive protein**

**Issue**

With a growing population, the expansion of urban areas, and the depletion of natural resources, food processors face the challenge of creating industries that minimize waste, cut pollution, reduce energy consumption, and comply with or exceed regulations. The approaching exhaustion of petroleum, which has provided a cheap source of energy and raw materials for decades, has driven the interest for alternative sources of biofuel like biodiesel and ethanol. Production of biofuels will require the expansion of crops that eventually will introduce vast amounts of byproducts in the market that will compete with the traditional byproducts from food production. Therefore, it is critical to develop new applications for byproducts from the food industry, especially from the protein sector.

**Action**

In response to the need for new applications for byproducts from the food industry, researchers at University of Arkansas have been working on the depolymerization of insoluble protein byproducts from different sources using environmentally friendly techniques. Enzymes and superheated water have been used to hydrolyze protein byproducts from the poultry industry to different degrees of hydrolysis, which generates free amino acids and peptides with various functionalities.

**Impact**

The first step in the hydrolysis of insoluble proteins is the liquification of the material followed by the breakdown of the protein chains. Understanding the factors that influence this process is critical in the production of peptides of different molecular weights that eventually will lead to the development of new applications. The ultimate goal of this research will be the development of new products and applications to add value to byproducts from the poultry industry and other sources of protein.

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**Funding**

HATCH; Division of Agriculture, University of Arkansas

## **Healthy conjugated linoleic acid (CLA)-rich soy oil produced by a new pilot plant-scale method**

**Issue**

Dietary CLA is well recognized for its anti-carcinogenic, anti-atherogenic properties and ability to increase lean body mass and protect against immune-induced body wasting disease, chronic inflammatory diseases, and cancer. Dairy and beef products are regarded as the primary source of naturally occurring CLA at levels at 0.2-2% in milk-fat or beef-fat. However, the current human intake of CLA is proposed to be 10 times less than the 3g/day minimum value proposed to have optimal human health benefit, as extrapolated from animal studies. Obtaining this level of CLA from naturally occurring sources of beef and dairy products would increase the total fat and saturated fat intake and increase the negative health risks associated with dietary saturated animal fats. The production of a more concentrated CLA source in a readily available food with minimal saturated fat would therefore be beneficial. Soy oil is an obvious candidate to make CLA-rich oil as it consists of 50% linoleic acid (LA) from which CLA is made. It is relatively low in saturated fat and is the most commonly used oil in the U.S.

An innovative processing technology using light energy to convert soy oil LA to CLA has been developed in the laboratory to produce a 20% CLA soy oil, without loss in oil quality. Unfortunately, the laboratory-scale system takes almost a week to produce less than a liter of oil. There is a need to develop a faster, larger scale pilot-plant system.

**Action**

We have built a pilot plant-scale facility for large-scale production of CLA-rich oil and evaluated the oil quality and optimized production conditions to produce many liters of 20% CLA-rich soy in less than a day. A novel, innovative feature of processing is ultraviolet illumination of a laminar oil flow that makes larger scale, faster conversion of soy LA to CLA possible and is much more efficient than the laboratory system. Furthermore, pilot-plant processing does not adversely affect oil quality.

**Impact**

The pilot plant system is a significant advance in producing CLA-rich soy oil and an important step in moving toward commercialization and providing consumers with the health benefits of increased CLA intake, without increasing total fat, saturated fat, and cholesterol intake. The oil could be used for frying, in salad oils, blended with regular soy oil, or used as a concentrated dietary supplement.

**Funding**

U.S. Department of Agriculture; National Research Initiative; Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas

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#### Funding

Division of Agriculture, University of Arkansas

### CLA-rich potato chips: A healthier snack food

#### Issue

Dietary conjugated linoleic acid (CLA) is well recognized for its anti-carcinogenic, anti-atherogenic properties and ability to increase lean body mass and protect against immune-induced body wasting disease, chronic inflammatory diseases, and cancer. Dairy and beef products are regarded as the primary source of naturally occurring CLA at levels at 0.2-2% in milk-fat or beef-fat. However, the current human intake of CLA is proposed to be 10 times less than the 3g/day minimum value proposed to have optimal human health benefit, as extrapolated from animal studies. Obtaining this level of CLA from naturally occurring sources of beef and dairy products would increase the total fat and saturated fat intake and increase the negative health risks associated with dietary saturated animal fats. However, the production of a more concentrated CLA source has been achieved with minimal saturated fat by converting soy oil linoleic acid to CLA by a simple processing method using ultraviolet light. Soy oil is the most common oil in the U.S., consisting of 50% linoleic acid (LA) and has been used to produce a 20% CLA soy oil that is naturally low in saturated fat. However, the problem is how best to incorporate the CLA-rich soy oil into common foods.

#### Action

We have shown that CLA-rich oil can be used in potato-chip frying operations and the residual oil in the chips has the same CLA content as the original oil, with no loss in quality relative to the original product.

#### Impact

A one-and-a-half ounce serving of the chips would provide the estimated human daily CLA requirement, without the saturated fat found in dairy and meat products that would accompany the same dose of CLA in dairy and beef products. Thus, a moderate portion of this snack food could play an important role in healthy diet. These findings have been featured in various food industry publications and a major Arkansas state television station. A major snack food company has expressed interest in this project.

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#### Funding

Division of Agriculture, University of Arkansas

### Dietary antioxidants and heart disease

#### Issue

Radical scavenging antioxidants are regarded as being important in delaying low density lipoprotein (LDL) lipid oxidation, which results in heart disease. Antioxidant performance is commonly evaluated by delaying oxidation of a non-oxidized, freshly prepared low density lipoprotein from blood plasma. However, LDL of heart disease patients may have partially oxidized LDL and, therefore, antioxidant performance in it may be very different from that of unoxidized LDL from healthy individuals.

#### Action

The effect of common antioxidants on oxidation of partially oxidized LDL was compared with the effect on a fresh LDL control. LDL was isolated from the blood of healthy individuals and oxidized to varying degrees in the laboratory. The effectiveness of the common dietary antioxidants catechol and alpha-tocopherol in stabilizing the oxidized and fresh LDL was evaluated. Catechol and alpha-tocopherol effectively stabilized the non-oxidized, fresh LDL control samples. However, a pro-oxidant effect was observed when they were added to LDL in the early stages of lipid oxidation and no effect was observed when antioxidants were added after severe oxidation.

#### Impact

The ability of antioxidants to stabilize LDL was dependent on the degree of LDL oxidation. Therefore, administering dietary antioxidants to heart disease patients should be carefully considered since their LDL may be less stable. It would be helpful to investigate the effect of antioxidants in stabilizing LDL obtained from heart disease patients.

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#### Funding

Arkansas Biosciences Institute; Division of Agriculture, University of Arkansas

### Antibiotic-resistant bacteria in a stream receiving wastewater treatment-plant effluent

#### Issue

Incomplete elimination of antibiotics and bacteria in wastewater treatment plants (WWTP) has been reported. Mud Creek in Fayetteville, Ark., receives effluent from a local WWTP. Antibiotics have been measured in Mud Creek.

However, the antibiotics detected have been measured at very low levels (<1 ppb). Whether there are measurable impacts of antibiotic-resistant bacteria and low levels of antibiotics from WWTP effluent on microbial communities in aquatic ecosystems is not well quantified.

#### Action

Total antibiotic-resistant coliforms and *Escherichia coli* most probable numbers (MPN) were determined in Mud Creek upstream, at 2 locations downstream, and from within the effluent input. The antibiotics ofloxacin, sulfamethoxazole, and trimethoprim have been detected at low levels (<1 ppb) and MPN in the absence or presence of ofloxacin, sulfamethoxazole, trimethoprim, or tetracycline were enumerated three times in summer 2007. Results varied by antibiotic, stream location, and sampling time. While numbers were low, about one-third of the *E. coli* detected in the effluent was resistant to sulfamethoxazole or trimethoprim. Proportions of resistant *E. coli* measured at the second downstream site were not higher than upstream, but sulfamethoxazole-resistant coliforms were higher downstream than upstream. Ofloxacin resistance was very low.

Resistant bacteria were introduced from the WWTP effluent. While antibiotic resistance tended to decrease further downstream, it was not always similar to or lower than upstream. Further study is being pursued to determine the extent to which effluent introduces and impacts antibiotic resistance in bacteria in the environment.

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#### Funding

USGS/Water Resources Research Institute; Division of Agriculture, University of Arkansas

## Identification of bacterial pathogens collected from Arkansas dog hosts

#### Issue

Arkansas contains more than 50 state parks, providing outdoor recreation for countless visitors, and habitat ideal for wildlife and tick species. The most commonly encountered ticks include the Lone Star tick, the blacklegged tick, and the American dog tick. Many of these locations provide habitat for wildlife that potentially serve as reservoirs for bacterial pathogens including Canine ehrlichiosis (*Ehrlichiosis* spp.), Lyme disease (*Borrelia burgdorferi*), Rocky Mountain spotted fever (*Rickettsia rickettsii*), and Tularemia (*Francisella tularensis*). These pathogens are readily vectored by ticks to domestic and wild animals, dogs, and humans. Tick-borne pathogens are common across the country, but their presence in ticks and animals has not been documented in Arkansas, despite the state ranking among the highest

in reported human cases of tick-borne diseases.

#### Action

The presence of vectors, hosts, and pathogens in neighboring states may indicate a high probability of pathogen incidence, prevalence, and transmission in Arkansas. During 2007, ticks were collected from canine pets by cooperating veterinarians throughout Arkansas and adjacent states. The collections came from dogs (with blood samples) and 1300 ticks, representing several species (*A. americanum*, *A. maculatum*, *Ixodes scapularis*, and *D. variabilis*), were obtained from counties throughout Arkansas and 1 county in Missouri. Ticks collected from dogs ranged from 1 tick to 24 ticks per animal. Genetic analysis of the ticks has been performed on more than 500 ticks; genetic sequences indicate 2 haplotypes for *A. americanum* and 1 haplotype for *I. scapularis*. Fortunately none of the canines tested positive for any of the pathogens listed above; however, tick samples contained remarkably high percentages of pathogens, including *Borrelia burgdorferi* (average of 7% of all ticks), *R. rickettsii* (33%), and *F. tularensis* (18%). Most positive ticks were adults.

#### Impact

The data obtained from the study will provide insight into tick-canine-pathogen interactions. We hope for the establishment of a database with current records updating tick diversity, colonization, and basic biological data. These data will provide information needed to develop integrated tick management strategies relevant to Arkansas residents, tourists, and pets.

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#### Funding

Division of Agriculture, University of Arkansas

## Structure/functionality relationships of granule architecture and swelling/leaching of starch

#### Issue

Starch is the major component of staple foods and is one of the most versatile ingredients in the food industry. Structural changes of starch during processing and storage are critical to food quality and stability. Gelatinization and swelling of starch provide desired functionality to foods, but leaching and fragmentation often result in undesirable changes in quality and stability. The texture and quality of starch-containing foods are mainly controlled by the state of starch granular disorganization. Therefore, it is critical to understand the factors that control starch swelling and maintain starch integrity. Presently, the information on the composition/structure of leached components in relation to food quality and stability is limited.

#### Action

Food science researchers at the University of Arkansas have shown that the molecular structure responsible for



maintaining starch integrity during gelatinization and swelling is not constant but dynamic. Upon gelatinization, starch molecules become mobile and are capable of interacting or associating with each other. At the same time, smaller molecules, either more linear or with smaller hydrodynamic volume, can leach out. When temperature increases, starch absorbs more water and starch molecule mobility increases accordingly. Nevertheless, molecules cannot leach out freely because of the presence of a screen-like surface. Larger Mw molecules are more likely to become entangled and stay at the surface as part of the granule envelope, whereas lower Mw molecules more easily leach out with increasing temperature. When the amount of starch molecules are not sufficient to maintain granule integrity during continuing swelling, starch granular structure eventually collapses and forms fragments (i.e. ghost remnants) with the larger Mw molecules still constituting the ghost remnants.

#### **Impact**

Understanding the mechanism of starch swelling and leaching is critical in the development of novel starches with desired functionality by way of plant breeding or modern biotechnology. This study provides fundamental knowledge on what really controls swelling and integrity of starch. The knowledge gained from this work will allow advances in applied research with major breakthroughs in starch research. Plant breeders and biotechnologists will also be able to select the appropriate genes or enzymes to manipulate the biosynthesis of starch with controlled structure and targeted properties. The ultimate goal of this study is to produce improved quality foods by permitting rational modification of processing methods, and by providing targets to enhance the value of raw materials.

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#### **Funding**

United States Department of Agriculture; Division of Agriculture, University of Arkansas



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# A Safe and Secure Food System

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## Crop biosecurity depends on pest detection networks

### Issue

Crop agriculture in the U.S. has become more dependent on fewer growers and large monocultured systems. Globalization of agriculture, increased travel, and the changing climate have made our crop production systems more susceptible to invasive pests and changes in endemic plant diseases over time. Recent examples that have impacted Arkansas have included karnal bunt in wheat; a new race of stripe rust of wheat; sudden oak death; the threat of bakanae disease of rice; the recent discovery of panicle rice mites; and the introduction of Asian soybean rust in 2004. Early detection and monitoring are essential to prevent major interruptions in food production.

### Action

In cooperation with USDA/CSREES and other agencies, the University of Arkansas Division of Agriculture has continued to upgrade the Plant Health Clinic near Lonoke, Ark.; enhance biosecurity education programs; develop action plans; and train first detectors. Recently, we purchased a database management system called DDDI that will allow networking of our plant diagnostic services in the state with other services around the country. We added new technology to enhance plant diagnostic services, including new microscopy, and DNA- and antibody-based testing. These actions strengthened our educational programs in Plant Health and provided more trained First Detectors in the state and a greater understanding of plant diseases and other pests—including those that might be invasive. These actions also strengthened our relationship with other state and federal diagnostic and monitoring programs.

### Impact

Educational and service aspects of plant diagnostic services in Arkansas have led to more comprehensive monitoring and potential early detection of crop threats. We now have qualified first detectors for Asian soybean rust and other invasive problems in every county. Upgrades to plant diagnostic facilities in the state have resulted in faster and more accurate service to Division clientele and reduced the need for external help when working with regulatory and other agencies. In time, these efforts should improve our overall crop biosecurity and allow us to continue to produce a dependable, economical, and safe food supply.

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University of Arkansas Cooperative Extension Service;  
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USDA/CSREES/UFL SPDN

## Extending the retail shelf life of ground beef

### Issue

The United States produces approximately 3.6 billion kg of ground beef per year with a gross retail value of about \$12 billion. Ground beef is a staple in consumers' diets, but it has a significant drawback—its very short retail display life of about 2 days. It is estimated that more than \$75 million of ground beef is lost annually because it is deemed unacceptable by most consumers because it lacks a bright-red color. To consumers, color has been shown to be the single most important consideration when purchasing ground beef.

### Action

Non-thermal processes are used to extend the shelf life of ground beef. However, many of these processes destroy the bright red color that consumers use as their primary quality criterion. The objective of our research was to further extend ground beef retail display life using antioxidants, reductants, and/or TSP treatments combined with electron-beam irradiation. Ground beef was produced with added butylated hydroxyanisole (BHA) plus butylated hydroxytoluene (BHT) in combinations. Half of the treated samples were irradiated at 2.0 kGy- under a nitrogen atmosphere, half were non-irradiated. Samples were displayed under atmospheric oxygen in a simulated retail display (SRD) case. Controls had the highest thiobarbituric acid reactive substances value and the lowest redness (CIE a\*), proportion of oxymyoglobin and vividness. Treated irradiated samples were just as red and vivid on day 9 of the simulated display as the non-irradiated untreated control at day 0. Treatments stabilized color and lipids of ground beef after irradiation and during SRD.

### Impact

The bright-red color in beef is perceived to be fresh and safe as opposed to an oxidized brown color. This research offers the possibility of significantly increasing the shelf-life of ground beef beyond the current 2-day shelf life. This could provide significant reduction of waste for retailers and

significant savings for beef producers and consumers.

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#### Funding

HATCH Project: 0186582 CSREES ARK ARK 02082;  
Division of Agriculture, University of Arkansas

## Strategies to eliminate *Campylobacter* colonization in poultry

#### Issue

*Campylobacter* is one of the most commonly reported bacterial causes of human foodborne infections in the United States with an estimated 2.1 to 2.4 million cases reported annually. Epidemiological evidence indicates that a significant proportion of human infections result from the improper preparation of poultry products. The cost of poultry-associated cases of campylobacteriosis in the U.S. is estimated from \$360 to almost \$700 million annually. Numerous studies have shown that a substantial number of retail chicken and turkey products are contaminated with *Campylobacter*. Despite commendable progress achieved in food safety through pathogen reduction programs, the commensal relationship between *Campylobacter* and poultry makes control measures against them difficult. Therefore, innovative on-farm strategies for preventing colonization of birds are critical to prevent the contamination of poultry products with these pathogens.

#### Action

Our laboratory at the University of Arkansas is at the forefront of investigating preharvest strategies to reduce *Campylobacter* contamination in poultry. One of our major focuses is evaluating and developing strategies utilizing natural antimicrobial compounds. We have been successful with numerous compounds including demonstrating the efficacy of bacteriocins (proteins naturally produced by bacteria that kill or inhibit the growth of other bacteria). Recently we have explored the effectiveness of Caprylic acid, a natural fatty acid present in breast milk and coconut oil that is a food-grade chemical approved by the FDA as Generally Recognized As Safe (GRAS). Published literature has demonstrated that caprylic acid is very effective in killing a variety of pathogenic bacteria. We conducted a series of studies to evaluate the ability of caprylic acid to reduce *Campylobacter* population in chickens. We found consistent reductions in *Campylobacter* colonization. The therapeutic results are particularly significant because there are few successful strategies to reduce *Campylobacter* in the live bird once they are contaminated.

#### Impact

The results demonstrate both therapeutic and prophylactic supplementation of caprylic acid in the feed can effectively reduce *Campylobacter* in poultry and may be a potential treatment for reducing pathogen carriage in poultry. The

ability of these naturally occurring proteins to reduce *Campylobacter* in birds may provide an important tool to provide a safer food supply to consumers. Use of caprylic acid in poultry would be predicted to reduce the incidence of *Campylobacter* infections by 30-fold, resulting in reduced human suffering and medical savings of tens of millions of dollars.

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#### Funding

Division of Agriculture, University of Arkansas

## Thermal processing of ready-to-eat meat products

#### Issue

Approximately 76 million cases of illness are caused every year due to foodborne pathogens, according to the Center for Disease Control and Prevention. Many of these illnesses result from improper cooking of food products by the consumer, but some arise from improper thermal processing of ready-to-eat meat products by the food industry. The food processing industry needs tools to help them determine appropriate processing conditions to guarantee the safety of ready-to-eat products.

#### Action

Experiments in the Bio-Safety Level 2 laboratory in the Biological & Agricultural Engineering Research Laboratory are being conducted to determine basic parameters for thermal destruction of a variety of pathogens in combination with a variety of ready-to-eat food products.

#### Impact

The studies will enable food processors to develop antimicrobials that can be applied to the ready-to-eat product just before packaging, thus producing a safe, ready-to-eat product.

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#### Funding

Industry grants; Division of Agriculture, University of Arkansas

## Development of a novel bacterial-vectored vaccine against avian influenza

#### Issue

Avian influenza (AI) is a significant public health concern and a serious economic threat to the commercial poultry industry worldwide. In the last five years, there has been a substantial increase in the number of AI outbreaks in poultry flocks, and the number of birds affected in AI outbreaks has increased 100-fold, mostly in Asia. Current



influenza vaccines target antibody production against the surface glycoproteins, hemagglutinin (HA) and neuraminidase. However, these antigenic molecules are highly susceptible to recombination (shift) and mutations (drift). This results in the need to frequently update the vaccine to protect against currently circulating strains. Therefore, there is a critical need for new influenza vaccines that are able to provide protective immunity against current and future AI virus strains.

#### Action

Candidate bacterial-vectored vaccine strains were developed which express a conserved outer-membrane protein sequence from avian influenza on the bacterial cell surface. Due to the potential of the bacterial vector to cause infection, two virulence genes were deleted for attenuation purposes. The candidate vaccine strains were then used in experimental studies to determine serum antibody titers to the presented polypeptide, persistence of the vector within the host, and ability of the candidate vaccine to protect against direct high- and low-pathogenicity avian influenza challenge. In initial evaluations, the candidate vaccine demonstrates significant promise. This is especially true for those isolates that threaten the United States poultry industry each year.

#### Impact

Increasing the resistance of the poultry population against AI will not only prevent substantial economic losses to the poultry industry due to the high morbidity and mortality associated with AI in poultry flocks, but will also reduce the significant health risk for the human population as well. As certain avian influenza outbreaks could immediately close state borders to poultry export, a marked effect on the entire state economy could be felt. If commercialized and used, this vaccine approach could reduce the likelihood of infection within Arkansas or could reduce transmission during cleanup after an outbreak.

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#### Funding

Division of Agriculture, University of Arkansas

### Development of a novel bacterial-vectored vaccine against *Salmonella*

#### Issue

*Salmonella* continues to be one of the most commonly reported bacterial causes of human foodborne infections worldwide, and epidemiological evidence indicates that poultry and poultry products are a significant source of human infection. In contrast to humans, *Salmonella* infre-

quently causes apparent clinical disease in poultry flocks. However, infection in young chicks with some *Salmonella* isolates results in 2% mortality within the first 48 hours post-hatch, and up to 20% morbidity within the first 5 days. Researchers have previously demonstrated that poultry flocks that are not infected with *Salmonella* prior to slaughter will not become contaminated unless processed after positive flocks. Therefore, pre-harvest intervention through the use of efficacious vaccination programs that can effectively protect poultry against multiple serovars is one important strategy for reducing the contamination of poultry products with this foodborne pathogen. An important part of the problem is that there are several dozen *Salmonella* serovars that commonly infect commercial poultry. As traditional vaccines only protect against a single (or very limited number) of *Salmonella* serovars, this has greatly limited the effective use of vaccines under commercial conditions.

#### Action

With specific, competitive USDA NRI funding for this project, candidate bacterial-vectored vaccine strains were developed which express a conserved flagellar antigen sequence from *Salmonella* on the bacterial cell surface. This antigen shares extensive homology with many *Salmonella* serovars as well as *Shigella* and *E. coli*. Due to the bacteria's potential to cause infection, two virulence genes were deleted for attenuation purposes. The candidate vaccine strains were then used in experimental studies to determine serum antibody titers to the cell surface-expressed antigen and persistence of the vector within the host. Early results indicate that vaccinated birds clear the systemic infection very quickly after even very high challenge levels with wild-type *Salmonella* isolates.

#### Impact

Increasing the resistance of the poultry population against *Salmonella* will not only reduce the impact of low-level disease on performance associated with *Salmonella* in poultry production but will also significantly reduce the potential of poultry products contributing to human foodborne illnesses within the human population. In the United States, it is estimated that 1.4 million humans contract salmonellosis each year, and that the annual cost of this illness, including lost productivity, is \$3 billion (WHO, 2006).

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#### Funding

Division of Agriculture, University of Arkansas

### Grapeseed extract and nisin, with and without malic acid and EDTA incorporation in the whey protein film,

## **inhibit the growth of *Listeria monocytogenes*, *E. coli* 0157:H7 and *Salmonella* Typhimurium in ready-to-eat meat product**

### **Issue**

Food safety is a growing concern to the consumer and food industry. There have been several outbreaks of foodborne illnesses reported every year in the U.S. This can be attributed to an increase in the use of minimally processed ready-to-eat food with extended shelf life. Ready-to-eat foods are vulnerable to recontamination with *L. monocytogenes*, *E. coli* 0157:H7, and *Salmonella* Typhimurium during handling. Edible film and coatings can serve as carriers for a wide range of food additives, including various antimicrobials that can extend product shelf life and reduce the risk of pathogenic spoilage organisms on a wide variety of ready-to-eat foods.

### **Action**

Food Science researchers at the University of Arkansas Division of Agriculture incorporated grape seed extract (GSE), nisin (N), malic acid (MA), and EDTA alone and in combination in the film-forming whey protein solution. Turkey frankfurter samples inoculated with the three pathogens (*L. monocytogenes*/ *E. coli* 0157:H7 /*Salmonella* Typhimurium, 7 logs CFU/ml) after drying under laminar flowing conditions were dipped in the above WPI coatings. Samples were stored at 4°C for 28 d and colonies were enumerated on d 0, 7, 14, 21, and 28.

*L. monocytogenes* population was decreased by 4.8 log cycle after 28 d at 4°C in the samples containing nisin with GSE, and MA, whereas the control (without WPI coating) was increased to 8.16 log CFU/ml. *Salmonella* Typhimurium population decreased by approximately 2 logs cycles after 28 d at 4°C in the samples coated with WPI containing combinations of N, MA, GSE and EDTA. However, in *E. coli* 0157:H7, the most effective inhibition (2.8 log cycle reduction) was observed with WPI coating containing N, MA, and EDTA.

### **Impact**

These findings demonstrated that the use of an edible film coating containing nisin, organic acids, and natural extracts is a promising means of controlling the growth and recontamination of *L. monocytogenes*, *Salmonella* Typhimurium, *E. coli* 0157:H7 on ready-to-eat meat products.

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### **Funding**

Food Safety Consortium, USDA; Division of Agriculture, University of Arkansas

## **Nanoparticles-based fluorescent biosensor for rapid detection of *Listeria monocytogenes* in foods**

### **Issue**

*Listeria monocytogenes* is one of the major foodborne pathogens and has relatively high heat resistance and salt tolerance and the ability to grow at refrigeration temperatures and over a wide range of pH. The CDC estimates that 2,500 cases of human listeriosis occur annually in the U.S. with a case fatality rate of 20% that leads to an estimated 500 deaths per year with a projected cost of \$233 million. USDA/FSIS issued a zero-tolerance policy for *L. monocytogenes* in ready-to-eat foods. To control *L. monocytogenes* in foods and to meet the federal regulations, food industries need a rapid, sensitive, specific, and inexpensive method to detect *L. monocytogenes* in food products on-line or even in real time.

### **Action**

The objective of this project is to develop a nanoparticle-based fluorescent biosensor for rapid detection of *L. monocytogenes* in foods. The biosensor system consists of a novel nanobeads bioseparator, novel quantum dots biolabels, and a fluorescent detector. The nanotechnology-based biosensor is evaluated for the food industry to screen *L. monocytogenes* in poultry, meat, and vegetables, specifically ready-to-eat food products. The result showed that magnetic immuno-nanobeads could capture target pathogenic bacteria in foods with more than 90% capture efficiency in 15 min, which is advantageous over magnetic immuno-microbeads as well as centrifuge and filtration. Quantum dots nanoparticles were coated with anti-*Listeria* antibody and used as fluorescence labels in the immunosensor, which gave more than 100 times fluorescence emission compared to common fluorescent materials used in immunoassays. The fluorescent intensity measured is proportional to the concentration of *Listeria* cells in a range of 1 to 10<sup>6</sup> cfu/ml. A totally automated instrument, which consists of a nanobioseparator, a flow-through microfluidics chip, and an optical detector, has been designed and fabricated for this biosensing technology. Anti-*L. monocytogenes* monoclonal antibodies and rapid-growth medium are being developed to meet the required specificity (strain level), sensitivity (1 cfu/ml), and time (less than 2 hrs). This biosensing method is also able to simultaneously detect multiple pathogens in a food sample.

### **Impact**

The food industry and federal regulatory agencies can apply this novel biosensing method to food safety inspection and quality control to ensure food safety and security. Our society could benefit from this technology in terms of reducing foodborne diseases and consequently related medical costs. Application of the new nanotechnology-based biosen-

sor would enable the food industry to benefit economically in terms of prevention of product recalls and international embargos associated with the microbial contamination of food products.

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#### Funding

USDA/ARS and NAFSS; Division of Agriculture, University of Arkansas

### A microfluidic immunosensor for rapid detection of multiple foodborne pathogenic bacteria in poultry products

#### Issue

Contaminated food, mainly by pathogenic microorganisms, is estimated to cause 76 million illnesses, 325,000 serious illnesses resulting in hospitalization, and 5,000 deaths in the U.S. each year. USDA/ERS estimates the medical costs and productivity losses associated with *E. coli* O157, *Salmonella*, *Listeria monocytogenes*, and *Campylobacter* alone amount to at least \$6.9 billion annually. Current methods for detection of bacteria rely upon culture plating, ELISA, and PCR. However, these methods are time consuming, expensive, or not specific, and require trained operators with laboratory facilities. There is an urgent need for a rapid method to detect major foodborne pathogens.

#### Action

An immuno-electrochemical biosensor system coupled with immuno-magnetic separation was first developed for detection of *S. Typhimurium* in poultry products. The biosensor can enumerate *Salmonella* as low as  $1 \times 10^2$  cell/ml in 2 h. A bienzyme electrode was developed for the biosensor to improve sensitivity. A capillary bioseparator/bioreactor was then studied to enhance the binding efficacy of antibodies/antigens and enzymatic reaction, and to design an automated instrument. Microfluidic channels were also applied to replace capillary columns to further improve the biosensor's performance. The immunosensor has been evaluated for the detection of *S. Typhimurium*, *L. monocytogenes*, and *E. coli* O157:H7 in raw and cooked poultry products. The results showed the detection limit and time were 10 cells/ml and less than 1.5 h. The immunosensor showed its great potential to detect three target pathogens simultaneously. This biosensor has been further developed and commercialized by BioDetection Instruments (BDI) based on three patents filed by the University of Arkansas.

#### Impact

The results of this project could provide the food indus-

try with new technology to detect pathogens in foods in less than 1.5 hours with acceptable detection limits (less than 10 cells/ml or cells/g). The biosensor could be designed as a portable, hand-held instrument for use in a food-processing plant or a food market. The food industry could save millions of dollars annually by avoiding product recalls since this biosensor technology could reduce the microbial detection time from more than 24 hours down to 1-2 hours. Consumers could benefit from reduced foodborne sickness and associated medical costs. This technology will also help our society reduce foodborne diseases and strengthen the safety and security of our food supply system.

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### Nanobead/nanofiber-based impedance biosensor for rapid detection of foodborne pathogens

#### Issue

Foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the U.S. each year totaling a cost of \$7.7-8.4 billion. Conventional microbial detection methods for food inspection are time-consuming and expensive and cannot match rapid food processing and distribution systems. To minimize product recalls, clear international trade barriers, and prevent foodborne diseases due to microbial contamination, the food industry needs more rapid, sensitive, specific, and inexpensive methods to detect pathogens in food products on-line or even in real time. A rapid biodetection method is also urgently needed for monitoring our food supply system for its safety and security in anti-bioterrorism efforts.

#### Action

The biosensor consists of a sampler, multiple-section microfluidic cartridges, a pumping unit, an impedance detector, a microprocessor, a display, a key panel, and a USB connector to a laptop or PC. First, a food sample containing various biological and chemical components and different bacteria is mixed with magnetic nanobeads coated with specific antibodies under a rotating magnetic field to separate and concentrate target pathogens. The pathogens captured on nanobeads flow through a microfluidic channel and are captured by the antibodies immobilized on the nanofibers connected to the embedded microelectrodes. The key part of the biosensor is TiO<sub>2</sub> nanowire/nanotube bundles that are immobilized with antibodies through covalent bonding. The change in dielectric properties of the nanofibers, i.e., the

impedance change caused by captured target bacteria, can be measured and correlated to the cell number of *Listeria*, *Salmonella*, or *E. coli* O157:H7. Multiple bacteria may be simultaneously detected by placing multiple electrodes in the microfluidic channel and coating them with different antibodies. An invention disclosure has been filed.

#### Impact

The results of this project could provide the food industry with new technology to detect pathogens in foods in less than 1.5 hours with acceptable detection limits (less than 10 cells/ml or cells/g). The biosensor could be designed as a portable, hand-held instrument for use in a food-processing plant or a food market. The food industry could save millions of dollars annually by avoiding product recalls since this biosensor technology could reduce the microbial detection time from more than 24 hours down to 1-2 hours. Consumers could benefit from reduced foodborne sickness and associated medical costs. This technology will also help our society reduce foodborne diseases and strengthen the safety and security of our food supply system.

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BioDetection Instruments, LLC; Division of Agriculture, University of Arkansas

### Predictive models and quantitative risk assessment models for *Salmonella* Typhimurium and *Campylobacter jejuni* in poultry products

#### Issue

*Salmonella* Typhimurium and *Campylobacter jejuni* are two of the major human pathogens associated with poultry products, mainly due to microbial contamination, recontamination, or cross-contamination during production and processing. Each year in the U.S., about \$12 billion loss is estimated for the medical cost, lost productivity, recalls, legal fees, and loss of business due to the microbial contamination of meat and poultry products. The poultry industry needs more effective methods to determine microbial hazards, assess the risk in their HACCP programs and risk management, and evaluate intervention technologies applied to poultry production, processing, and handling systems.

#### Action

Experiments have been conducted to collect the data for *S. Typhimurium* and *C. jejuni* on chicken skins and in processing water with various conditions (temperature, time, age of water, chlorine level, chemical spray, and initial cell concentration). Predictive models have been developed for

survival/growth/destruction of *S. Typhimurium* and *C. jejuni* on chicken carcasses and in processing water. Experiments were also conducted for hatching process, providing the data on *Salmonella* contamination of eggs and chicks. A cross-contamination model for poultry chilling process was also investigated. A quantitative risk assessment model has been developed for poultry production, processing, and distribution based on both collected and reported data using Monte Carlo simulation with @RISK software. The risk model can present the probability of microbial hazards in terms of percentage of contaminated carcasses or pathogen level of each carcass for given processing conditions. Sensitive analysis can also rank the major sources of microbial contamination or the critical control points in a poultry production, processing, and distribution system. Interventions can be evaluated using the risk assessment simulation model coupled with predicted microbial models. A Web site is available for the introduction of the risk assessment model developed in this research ([www.uark.edu/ua/biorisk](http://www.uark.edu/ua/biorisk)).

#### Impact

The predictive microbial models will provide poultry processors with a powerful tool to analyze the survival/growth/death and cross-contamination of pathogenic bacteria on poultry carcasses and in processing water under various processing conditions. The microbial risk assessment model will assist the poultry processor in their HACCP programs and risk management in a quantitative way. In combination with on-line or real-time microbial detection technologies, the predictive model and quantitative risk-assessment model could make on-line risk analysis available, which would greatly help the poultry industry in their decision making for food safety. Consumers will benefit from safer poultry products, and the society will benefit from reduced foodborne diseases and related medical costs.

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### Elimination of *Listeria monocytogenes* during thermal processing of ready-to-eat poultry products

#### Issue

*Listeria monocytogenes* is one of the major foodborne pathogens, which may be associated with poultry products. The USDA Economic Research Service (ERS) estimates the medical costs, productivity losses, recalls, legal fees, and loss of business for diseases caused by five foodborne pathogens total \$6.9 billion per year in the U.S., and the projected cost



relative to *L. monocytogenes* alone was estimated at \$233 million each year. The elimination of pathogens in meat and poultry products could save up to \$12 billion annually in all associated costs. The USDA/FSIS regulations indicate a zero tolerance to *L. monocytogenes* in ready-to-eat (RTE) food products. Therefore, the poultry processing industry needs more effective technologies to ensure the elimination of *L. monocytogenes* during thermal processing.

#### Action

The goal of this project is to evaluate the thermal processing conditions in an air-steam impingement oven to eliminate *L. monocytogenes* from different shapes and sizes of RTE poultry products and provide the poultry processing industry and regulatory agencies with microbial kinetics and risk-assessment models for pathogen lethality validation of commercial thermal processes. Treatment schedules were designed to achieve the targeted pathogen reduction on various shapes and sizes of RTE poultry products, including chicken breasts, wings, nuggets, and strips, and the process lethality was evaluated at different time-temperature combinations in an air-steam impingement oven without compromising product quality and yield. A heat/mass transfer model coupled with pathogen kinetics has been developed to predict *L. monocytogenes* inactivation in RTE poultry products in an air-steam impingement oven as a function of time, temperature, pH, and moisture content. Computer simulation software is ready for use on the Internet. The predictive model will be further validated for thermal processing of RTE poultry products by conducting tests in commercial poultry processing plants.

#### Impact

This research will help the poultry processing industry in eliminating *L. monocytogenes* while minimizing the detrimental effect to product quality. With the optimized temperature-time combination for thermal processing of RTE products, the temperature to destroy *L. monocytogenes* could be guaranteed while the flavor and weight could be maintained; therefore, the poultry processor would obtain the pathogen-free products with the maximum yield for more profits. The predictive models will be able to assist the poultry processors in design of the cost-effective treatment schedule for complete elimination of *L. monocytogenes* in RTE poultry products to ensure food safety and security.

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## Institute establishes partnerships in food processing industry

#### Issue

The food processing industry continues to be the number one manufacturing sector employer in Arkansas. However, an increased emphasis is needed on research and technology transfer to solve problems and expand opportunities for further processing of agricultural commodities in Arkansas and the region. Adding value by further processing increases the economic benefits of agricultural production. Creative organizational approaches are needed to increase involvement of the food processing industry in land-grant university research, Extension, and education.

#### Action

The University of Arkansas Division of Agriculture in 1995 established the Institute of Food Science and Engineering to assist food processors in framing issues, focusing efforts, and solving problems. The Institute promotes and supports research to assist industry in solving its research problems, both fundamental and applied. The goal is to create partnerships among private companies or industry groups and university scientists and Extension specialists from a variety of disciplines and departments, transcending traditional institutional boundaries that can be barriers to cooperation. The Institute's multidisciplinary research expertise offers an integrated approach to developing and disseminating scientific information associated with production, value-added processing, safety, nutritional value, packaging, storage, and distribution of food products.

The Center for Food Processing and Engineering's primary objective is to facilitate research leading to value-added products and improving the efficiency and effectiveness of the processing of agricultural products. Activities of the Center for Food Safety seek to maintain or improve the safety of foods through production, harvest, processing, distribution, and storage. A new emphasis is creatively applying fundamental-based science to resolving food safety issues. More natural and less-known host defenses and host preventive strategies are being investigated as important components for manipulation and application in food safety programs. The Center for Human Nutrition and Functional Foods evaluates value-added functional foods with elevated levels of health-promoting compounds. Its main thrust is the evaluation and enhancement of important phytochemicals present in fruits, vegetables, grains, and legumes grown in the southern region of the United States.

#### Impact

The Institute of Food Science and Engineering has sponsored 92 specific research projects, in addition to general research in eleven major research program areas, in the past twelve years, partnering with 146 companies from 34 states and seven foreign countries.

Arkansas is the leading rice-producing state. Thirty-four major rice-processing companies, accounting for the vast

majority of rice processed in the United States, have financially supported the Rice Processing Program sponsored by the Institute. Rice processors have never before participated in a joint research program "for the good of the industry" on this scale. The Program encompasses five main areas of research emphasis: drying, storage, milling, quality assessment, and the cereal chemistry of rice and rice products. Rice processors are gaining new understanding of factors that affect yield and quality of processed rice products. This information is impacting operations ranging from harvesting and storage of head rice to milling operations and storage of processed products. The economic benefit of this research is tremendous. As an example, a single project promises an improvement in head rice yield that could increase industry returns by \$7 million annually.

Other major program areas are processing of vegetables and fruits; wine and other grape products; pickled vegetables; rheology and sensory, functional foods; thermal processing of value-added poultry products; lipids and oils; and soy products. Completed sponsored projects in the area of vegetable processing provide industry with millions of dollars of increased returns annually. The patented vineyard mechanization systems have been commercialized. The fifth year of field trials in California has been concluded, demonstrating labor cost reductions while maintaining or improving yield and fruit quality. When widely adopted, many millions of dollars will be saved annually. The thrust to provide small farmers and entrepreneurs with information about the production, development of affordable further processing techniques, and analysis of accessible marketing channels, etc., of and for value-added horticultural products continues. Publications include over 320 refereed articles and fifteen other publications.

UA resources developed or enhanced through Institute programs include a unique, professionally trained descriptive sensory panel for analysis of diverse food products; thermal processing capabilities; and a product development kitchen for product development and improvement. Food quality and safety activities have included joint efforts to assure that imported products meet U. S. standards for quality and safety.

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USDA Special Grants; multiple industry grants; Division of Agriculture, University of Arkansas

## Antimicrobial treatment of beef enhances safety and appearance

#### Issue

The frequent outbreaks of foodborne illnesses and safety

recalls for meat products have caused consumer concerns about the safety of meat they eat. In this context, adopting a decontamination step at the end of the production line may help eliminate incidence of pathogenic bacteria in the final meat products. Consumers demand not only product safety but also product qualities such as color, taste, and appearance. Therefore, the meat industry faces the challenges of providing microbial safety of meat products through effective and affordable decontamination technologies without changing the product quality.

#### Action

Beef steaks obtained from top sirloin butts were inoculated with *E. coli* and *Salmonella* Typhimurium ( $10^7$  CFU/g). The inoculated meat was then placed into a meat tumbler and decontaminated using 0.5% (w/v) cetylpyridinium chloride (CPC), 10% (w/v) trisodium phosphate (TSP), 4% (w/v) sodium metasilicate (NMS), and 3% (v/v) potassium lactate (KL) as single antimicrobial interventions. Then the decontaminated steaks were packaged and displayed under simulated retail conditions (4°C) and microbiological, sensory color, and instrumental color evaluations were carried out on d 0, 1, 2, 3, and 7 of display.

#### Impact

The tested antimicrobial treatments significantly reduced the microbial populations in inoculated beef. All the treatments had a similar overall color to the untreated control. Furthermore, TSP and NMS treatments outperformed the other treatments and improved the redness of beef steaks compared to the untreated control. Therefore, incorporation of these antimicrobial interventions prior to packing will not only improve the product safety but also will appeal to the consumer's product quality expectations.

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Arkansas Beef Council; Division of Agriculture, University of Arkansas

## Combining a prebiotic with an alfalfa molting diet to reduce hen stress and *Salmonella enteritidis* invasion

#### Issue

The number of cases of gastroenteritis due to *Salmonella* subspecies enterica serotype *Enteritidis* (*S. Enteritidis*) infections continues to persist in the United States. *S. Enteritidis* is invasive in poultry and therefore has the potential to contaminate eggs by transovarian transmission following colonization of the intestinal tract. Periodic clusters of contaminated eggs produced by laying hens may be related to stress incurred from specific management practices such as molting. Feed withdrawal historically was the primary method used in the layer industry to induce molting and stimulate

multiple egg-laying cycles in hens. The stress associated with feed withdrawal increased *S. Enteritidis* colonization, decreased fermentation in the gut, and increased *S. Enteritidis* organ invasion. Ideally, a molting approach was needed by the poultry industry that was as easy as simple feed deprivation but avoided the disruption of the protective microflora in the gastrointestinal tract and promotion of physiological stress to the bird during molting. For alternative, non-feed withdrawal molting diets to be commercially accepted by the poultry industry they must: 1) avoid the potential for feed refusal response by the hens; 2) provide a molt induction stimulus substantial enough to cause sufficient reproductive tract regression during the molt; 3) yield egg production and quality parameters in the second egg-laying cycle that are at least comparable to those typically achieved with feed withdrawal; 4) be readily available in the regions where the primary egg producers are located; 5) be economical with minimal feed processing required prior to feeding to laying hens. Meeting these criteria will require achieving a balance between efficient molting induction and retention and minimal disturbance of the gastrointestinal microflora.

#### Impact

Research results demonstrate that several alfalfa molt diet combinations as practical molting alternatives will minimize *S. Enteritidis* infestations in layer flocks and reduce physiological stress to the bird. Alfalfa as a molt-induction dietary source meets several of the commercial criteria for successively inducing molt and subsequently retaining egg production and quality during postmolt. Alfalfa offers several advantages as a potential molt diet over other proposed low-energy diets because it is readily available in most egg- and poultry-producing regions of the U.S. as a common high-quality forage fed to dairy cattle to achieve high protein levels for maximizing milk production. In addition, alfalfa cubes are commonly available as high-quality commercial horse feeds. This provides the poultry industry with a scientifically based rationale for a possible management molting alternative that reduces molting as a major risk for *S. Enteritidis* contamination but enhances the commercial benefits of a 2nd egg-laying cycle.

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Division of Agriculture, University of Arkansas

## Foodborne *Salmonella* Typhimurium survival and virulence expression during food processing

#### Issue

Salmonellosis is one of the most common foodborne diseases in the United States. Given that *Salmonella* can

originate from a wide variety of food production environments, reduction of this organism at all stages of food production is critical. This project has three components designed to address this problem. Our specific research program goal reflects an integrated approach for controlling *Salmonella* spp. and other foodborne pathogens at all stages of food production. The relative incidence of *Salmonella* spp. foodborne disease continues, despite the growing body of information regarding the most common contamination routes. During its life cycle, *Salmonella enterica* serotype Typhimurium can encounter various environmental stress conditions which may have dramatic effect(s) on its survival and virulence. Although there is considerable information regarding environmental signals that control growth and pathogenesis in animals and humans, little is known about the biology of *Salmonella* during food processing. Research is needed to determine the environmental factors that are critical for survival of this pathogen and therefore must be modified to prevent the early establishment of *Salmonella* in food processing environments and virulence expression under these conditions.

#### Impact

Our current food production *Salmonella* spp. research projects have emphasized studies on the growth, survival, and pathogenesis of the organism under conditions encountered during food processing. However, the success of *Salmonella* spp. in becoming re-established in the gastrointestinal tract of food animals during certain phases of food processing indicates that *Salmonella* spp. can competitively interact with the dynamics of the food matrix. Based on these observations, our plan is to continue to focus on *salmonellae* metabolism and genetic regulation of stress responses when grown under food processing conditions and determine how these overlap with expression of virulence when foodborne *Salmonella* spp. become pathogenic. The outcome of this research has implications not only for persistence of foodborne salmonellae in food processing, but raises practical issues regarding the choices of antimicrobials as intervention steps in processing. Issues we are now pursuing include whether thermal treatment predisposes salmonellae to be more resistant to particular antimicrobials and how these conditions might influence virulence and pathogenic characteristics of salmonellae. Molecular techniques will delineate some of the phenotypic responses we have observed thus far and examine virulence expression of *Salmonella* under typical food production and processing conditions.

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## ***Campylobacter jejuni* attachment influenced by pre-established biofilms**

### **Issue**

*Campylobacter jejuni* is the leading cause of foodborne bacterial diarrhea in the United States. There are approximately 2.4 million cases of campylobacteriosis each year. Because many cases are not reported, the actual number of cases per year is thought to be underestimated by 5 or even 10 times. The medical costs and loss of productivity associated with this disease is estimated to be \$1.2 billion annually. *C. jejuni* colonizes the gut of the chicken without causing disease or adverse effects on the health of the animals. Raw poultry products are considered to be a major source of *C. jejuni* infections in humans. Therefore, control of environmental sources of *C. jejuni* that can potentially infect chickens is crucial. An understanding of how this fastidious bacterium survives outside a host also can provide valuable information to design intervention strategies. Finally, detection strategies are necessary to ensure the safety of poultry products and provide information to risk assessors.

### **Action**

Since *C. jejuni* is a very fastidious organism and survival outside the host is limited, we investigated biofilms and stress adaptation as mechanisms of survival outside the host. *C. jejuni* was inoculated into four biofilm populations isolated from poultry environments and cultured at three temperatures. Survival of *C. jejuni* in some pre-established biofilms was extended versus *C. jejuni* survival in broth. But some biofilms were detrimental to *C. jejuni* survival. Density gradient gel electrophoresis (DGGE) analysis indicated differences in bacterial profiles depending on initial source and temperature of culturing, which may have had impacts on *C. jejuni* survival. Since no *C. jejuni* was detected on surfaces without pre-established biofilms, it was concluded *C. jejuni* was strictly a secondary colonizer. The results of this study show *C. jejuni* attachment to surfaces is facilitated by pre-established biofilms and biofilms may be important in transmission and prevalence of *C. jejuni*. Stress adaptation also can enhance survival outside a host. To investigate this, *C. jejuni* strains were exposed to acid conditions (pH=4.5), acid conditions and aerobic atmosphere, or starvation stress, allowed to recover, and again challenged with acid stress. The counts of acid-adapted, acid- and aerobic-adapted, and starvation-adapted cells that survived further acid stress were higher than those of non-stressed cells in some strains, but adaptation and survival were time and strain dependent. Expression of the virulence gene *cadF* was up-regulated by starvation stress while *cdtB* and *ciaB* were down-regulated. The proteomic study revealed that six proteins were synthesized due to starvation stress and eight proteins appeared to be absent. These results indicate *C. jejuni* surviving stress can increase chances of surviving further stress such as passage through the human gastrointestinal tract and stress may be a significant factor in inducing some virulence genes. Understanding differences in virulence and any basis for pathogenicity is strategic for finding targets for treatment. In

order to understand the importance of cytotoxicity in *C. jejuni* pathogenicity, we compared the active subunit of CDT of isolates from poultry sources and clinical patients. Additionally, the significance of invasion in pathogenicity was also evaluated and correlated to toxin production. We found no correlation in invasion abilities and cytotoxicity and the results also indicated *C. jejuni* may utilize more than one mechanism in causing disease and pathogenicity but is strain-dependent. Therefore, it would be necessary to target more than one gene to design a detection method that would be able to distinguish pathogenic from non-pathogenic *C. jejuni* strains.

### **Impact**

Reducing *C. jejuni* in the environment and improving detection methods can decrease the prevalence of campylobacteriosis, benefiting both producers and consumers. Since 1970, the consumption of chicken has more than doubled. Because innovations in breeding, mass production, contract farming, vertical integration, and marketing have made chicken more plentiful and affordable, the price of chicken has also decreased. Poultry and poultry products are the most affordable source of protein for many Americans. In order to keep these products safe for consumers, continuing research is needed to reduce *C. jejuni* in the environment and prevent cross-contamination.

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USDA/CSREES; Division of Agriculture, University of Arkansas

## **Economics of regulating food recalls**

### **Issue**

Food recalls are critical to keeping the nation's food supply safe. Recent high-profile food recalls have resulted in calls for increased oversight of the recall process, and several legislative proposals before the 110<sup>th</sup> Congress contain provisions that address the role of regulatory bodies in the recall process.

### **Action**

An economic model was developed to demonstrate the impact of recalls on food safety outcomes. The model shows that recalls are important for two reasons. One is that they help minimize harm when product failures occur. Another is that they provide financial incentives for the food industry to invest in safety. When recalls are justified, they force food manufacturers to remove product from the marketplace so fewer people get sick. In these cases it makes sense that regulatory bodies should be granted more control of the recall process in order to improve the manner in which recalls are conducted. Such is the stated intent of most proposals for changing the food recall system. However, the model shows that recalls can be justified by their incentive effect alone. In fact, recalls can be beneficial even when the social value of



the harm they mitigate is so small as to be less than the costs of carrying them out. In these cases, it is important that proposals designed to improve the recall process avoid unintended side effects. First, proposals should avoid redirecting regulatory resources toward recall oversight and away from other, more pressing, food-safety priorities. Second, it is important to avoid creating an environment in which agencies face a greater need to justify their recall requests. When the mitigation value of recalls is small, this may inadvertently prevent the initiation of recalls that could otherwise play a positive role in aligning incentives for safety.

**Impact**

This project provides insight into the economic trade-offs involved in firm and governmental policies toward food recalls. The direct impact is a meaningful contribution to a timely policy discussion that is of significant importance to food producers and consumers alike.

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USDA Economic Research Service; USDA CSREES Project Number ARK02034; Division of Agriculture, University of Arkansas



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# Greater Harmony Between Agriculture and the Environment

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## No-till rice-based rotation and carbon sequestration

### Issue

There is a growing interest in how to best slow the growth of or decrease atmospheric CO<sub>2</sub> content. One key strategy to doing this is the use of row crops to sequester carbon. In an effort to do this on a national basis, a *cap and trade* strategy has evolved. This approach encourages those industries that emit carbon into the atmosphere to offset this carbon by paying industries that remove carbon from the atmosphere. Agricultural row-crop production has enormous potential to sequester carbon via growing crops that produce significant biomass and return that biomass to the soil where it will decay, leaving the carbon behind. A well-known approach to this is no-till farming—an approach that is rarely used in rice production.

### Action

A long-term rotation study comparing conventional- and no-till treatments was established at the University of Arkansas Rice Research and Extension Center in 2000. This study is comprised of rice-based rotations that contain a rice phase every year, second year, and third year. Crop species that are rotated with rice range from high-biomass corn to low-biomass soybeans. Wheat that is a winter-grown, medium-biomass producer is included in two rotations. Soil samples were collected from this study and evaluated for their percentages of water stable aggregates. Aggregate samples were then evaluated for their carbon content.

### Impact

Percent water stable aggregates significantly increased in no-till plots when compared to conventional-till plots regardless of rotation. Total percent water stable aggregates increased as the frequency of rice in a rotation increased. Highest values were recorded in the continuous rice rotation that contained wheat as a winter crop. This was followed closely by the continuous rice rotation and the rice-corn rotation. Rotations with the lowest percentage water stable aggregates were those that contained rice every third year. Aggregate carbon content was significantly higher in the larger aggregates when plots were no-till managed but not different in the smaller aggregates. Increasing soil carbon content, or carbon sequestration, by adopting no-till rice production occurs from increases in total water stable aggregates and increased carbon content in larger aggregates. These increases are greatest when rice appears more frequently in a rice-based rotation.

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Arkansas Rice Research and Promotion Board; Arkansas Soybean Promotion Board; Arkansas Corn and Grain Sorghum Promotion Board; Division of Agriculture, University of Arkansas

## Mitigation of air pollution from concentrated animal feeding operations

### Issue

Air quality from confined animal feeding operations (CAFO) is an emerging issue which will affect the economic viability of animal agriculture all over the U.S. As a top poultry state and home to several poultry integrators, Arkansas would be a benchmark state for conducting research on air quality issues from poultry operations. Currently, the science behind CAFO emissions and mitigation is not completely understood. There are information gaps in methods used for estimating emissions, monitoring devices, models for house emissions, dispersion and fate, and mitigation strategies.

### Action

A UA Division of Agriculture research group is developing affordable and effective at-source mitigation strategies for controlling ammonia and particulate matter emitted from commercial broiler houses. We are focusing on those mitigation strategies that are non-hazardous to the birds and workers, easily disposable, and have minimal impact on water and air quality after disposal. Additionally, we will also focus on developing baseline emission data for various weather conditions, bird age, and bedding conditions.

### Impact

As the number two poultry state in the United States, Arkansas could be seriously impacted by the evolving air quality issues, if not addressed immediately. The financial liability of animal feeding operations that were either sued or fined by EPA has been huge. If we do not develop economically viable mitigation techniques, anticipated changes in air quality regulations could lead to the demise of poultry operations in Arkansas. Our research is expected to develop affordable mitigation strategies for ammonia emissions from broiler operations.

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#### **Funding**

Arkansas Agricultural Experiment Station; Division of Agriculture, University of Arkansas

### **Remote sensing of natural processes and environmental quality**

#### **Issue**

Water is a natural resource that is seriously impacted by anthropogenic factors such as urbanization and agriculture, and natural processes such as soil erosion, among others. Although there has been significant research into the processes that affect water quality, a lot is still unknown. A true evaluation of the effect of natural processes and anthropogenic factors on water quality will require monitoring of these processes and the changes they cause in the landscape.

#### **Action**

This research focus is on combining remote sensing techniques with transport models to capture the dynamic processes that affect water quality. One of the major research focuses is on modeling pesticide transport from agricultural land to surfacewater in the L'Anguille River watershed. We are also studying a remote sensing method to quantify stream-bank erosion processes and to understand the relative contribution of sediments from stream banks and upstream areas within the Beaver Lake watershed.

#### **Impact**

It is important to protect our natural resources for future generations. A clear understanding of the various sources of pollution of surfacewaters and the mode of action of these pollution sources is critical to develop remediation techniques or best management practices that would either control the pollution at the source or minimize the contributions from various sources.

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EPA Region 6; Division of Agriculture, University of Arkansas

### **Arkansas robber flies as biological control agents and insects of conservation concern**

#### **Issue**

Robber flies comprise one of the most diverse and conspicuous families of flies, with more than 1,000 species known from North America. Over the past half century,

these flies have become the focus of research as indicators of environmental health and as biological control agents. Most species have restricted ecological requirements and are locally distributed. Adult robber flies are aerial predators of many insects whereas the larvae are predators or parasites that feed on eggs, larvae, or pupae of other insects, particularly of white grubs.

#### **Action**

Before the present survey was started, only 42 species of robber flies were recorded from Arkansas. Recent collecting and analysis have resulted in a checklist of 131 species, of which 66 species were recorded for the first time from the state. The Arkansas robber fly fauna is most similar to the fauna of the eastern United States. Distributional and biological notes for *Orthogonis stygia* were recently published. Some Arkansas specimens previously considered *Efferia nemoralis* are actually *Efferia plena* (this revision was recently published).

Several robber fly species are rare in Arkansas, and they may deserve to be classified as species of special concern for conservation purposes. Work has been completed on a taxonomic revision of the poorly known genus *Ceraturgus* in North America, all species of which are rare throughout their ranges. A taxonomic revision of the genus *Atomosia* in North America is in press, which includes the description of rare new species known only from the endangered blackland prairie habitat of Hempstead County, Ark.

Work is also underway on descriptions of North American robber fly pupal cases. One manuscript is in press and another manuscript is near completion. Knowledge of immature stages will advance our knowledge of the basic biology and ecology of these important flies.

#### **Impact**

Robber flies are significant elements of the ecosystem. They are excellent candidates for ecological monitoring and potential biological control agents for pest grubs. Along with butterflies, tiger beetles, and dragonflies, robber flies are receiving increased levels of interest as a focus of conservation concern. Concern that destruction of specialized habitats has contributed to population declines among some species of robber flies has grown in recent years. Many remnant prairie areas across the state are protected as natural areas. Presence of rare robber flies may impact management of Arkansas' remnant prairies.

Conservation and biological control work cannot proceed without review of the state's robber flies. This project will summarize all that is known about the robber flies occurring in Arkansas and set the stage for further research of economic and conservation concern.

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#### **Funding**

Division of Agriculture, University of Arkansas; Arkansas Natural Heritage Commission



## Ozark subterranean insect diversity and protection of groundwater resources

### Issue

Subterranean ecosystems harbor a rich diversity of life that is critically imperiled and poorly documented. The goals of the Arkansas Subterranean Biodiversity Project are to discover and protect the underground biodiversity, investigate ecosystem processes of subterranean habitats, and preserve cave and groundwater resources.

### Action

Many cave systems, several containing federally endangered species, are being investigated by the Subterranean Biodiversity Project to understand and preserve the underground biodiversity of the Ozarks. Cooperators include the University of Arkansas Arthropod Museum, Arkansas Natural Heritage Commission, Arkansas Soil and Water Conservation Commission, Arkansas Department of Environmental Quality, Nature Conservancy, USDA Forest Service, U.S. Geological Survey, and U.S. Fish and Wildlife Service. The Arthropod Museum is a depository for collected arthropods. Project cooperators inventory underground and aquatic habitats, inventory karst features, survey caves and define recharge basins, monitor environmental quality, monitor cave populations, and create educational outreach tools and programs. Hundreds of Diptera identifications have been made, and a publication is in review.

### Impact

Ground water supplies 62% of the overall water demands of the United States, yet little is known about groundwater ecosystems. Groundwater habitats provide crucial ecological services and sustain rich endemic communities, 90% of which remain undescribed. Despite the importance of subterranean habitats, they have received very little study by the scientific community. Less than 10% of an estimated 1,000 obligate cave-dwelling species in the Ozark Plateau have been described. Little is known about the distribution of species and their limiting factors. Few food webs have been described, and nutrient dynamics are poorly understood. Knowledge of subterranean ecosystem dynamics is needed not only for the protection of the groundwater resource, but because its denizens are among the world's rarest and most endangered freshwater fauna.

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Arkansas Subterranean Biodiversity Project; Division of Agriculture, University of Arkansas

## Alternative residue management practice effects on soil moisture and soybean production

### Issue

Over-withdrawal of groundwater for irrigation and a

long history of cultivation and crop-residue burning are current agricultural practices that may threaten the long-term sustainability of soil and water resources in eastern Arkansas. Depletion of the alluvial aquifer and degradation of soil quality in eastern Arkansas will be critical management issues that need to be addressed in the very near future. It will be critical to find the balance between maintaining high agricultural productivity and maintaining, and potentially improving, environmental sustainability.

### Action

A long-term study was initiated in Fall 2001 to address the impacts of alternative residue management practices on soil quality and soybean production on a silt-loam soil in eastern Arkansas. As part of this larger study, a shorter study was recently completed investigating the effects of residue management [i.e., high and low residue level, burned and unburned residue, and conventional tillage and no-tillage] on soil properties, soil moisture dynamics, and soybean production in a wheat-soybean double-crop system in eastern Arkansas for two complete cropping cycles.

### Impact

Based on years four (2005) and five (2006) after initiating the original study, soil properties were not consistently affected by residue management, but no-tillage consistently conserved soil water more effectively than conventional tillage in the top 10 cm. Soybean yield was generally unaffected by any residue management treatments imposed. In 2006, the estimated net return from the high-residue/burned/NT/irrigated treatment combination was 26% greater than the high-residue/burned/CT/irrigated treatment combination. The more environmentally sustainable practice of no-tillage appears to be a viable, and potentially more profitable, alternative to the more common practice of conventional tillage.

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Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas

## Nutrient and metal runoff from poultry litter-amended pasture soil

### Issue

Most of the poultry litter generated in Northwest Arkansas is land-applied to tall fescue and bermudagrass pastures as an effective organic soil amendment and nitrogen fertilizer. Aside from nitrogen, poultry can supply a large amount of phosphorous and many essential plant micronutrients (i.e., Cu, Fe, Mn, and Zn) needed for proper plant growth. Metals are also added to the poultry diet to promote weight gain, increase egg production, and prevent disease; thus notable amounts of metals, such as As, Cd, Cr, Se, and Ni, as well as others, are present in poultry litter.

Therefore, the potential is high for nutrients and metals to run off from sloped land where poultry litter is managed by land application.

#### **Action**

To understand the runoff leaching potential in areas of intensive poultry production, it is imperative to continuously monitor runoff and runoff concentrations of nutrients and metals in response to multiple litter applications and natural precipitation. Since runoff can potentially occur anytime throughout the year, controlled rainfall-simulation experiments are inadequate to address seasonal and inter-annual runoff variability, which is needed to evaluate the long-term effects of repeated poultry litter applications. Therefore, a multi-year study was initiated in 2003 to continuously monitor and evaluate the effect of poultry litter application rate on runoff and runoff concentrations and loads of several plant nutrients (i.e., N and P) and metals (i.e., As, Cd, Se, Cr, Mn, Fe, Ni, Cu, and Zn) from tall fescue on a 5% slope.

#### **Impact**

Based on the first four years of data, poultry litter treatment differences pertaining to seasonal and annual runoff amounts and flow-weighted mean (FWM) concentrations and runoff losses of nutrients and metals occurred, but were variable and inconsistent throughout the study. During eight of 16 3-month seasons, FWM concentrations from all treatments exceeded the maximum contaminant level for drinking water. Results also indicate that reducing poultry litter application rate by 50% does not proportionally reduce runoff losses; thus simply reducing application rates in areas with a history of litter application will not ensure reduction of potential further surface- and ground-water impairment. Evaluating runoff water quality in response to natural precipitation over an extended time period may be key to ascertaining long-term impacts of surface-applied broiler litter.

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Dale Bumpers College of Agricultural, Food, and Life Sciences; Arkansas Water Resources Center; Division of Agriculture, University of Arkansas

### **A computer program to predict safe stages of development for draining rice fields**

#### **Issue**

Water costs for producing rice in Arkansas have been increasing in the recent past from a combination of increased depth to available water, increased fuel and energy costs, and two extremely dry summers. Ways to reduce these costs are needed very much. One way to reduce these costs is to drain rice fields for harvest at a time that will allow water savings and a low likelihood of reducing rice yield or quality.

#### **Action**

A computer program to drain rice fields based on stages of development has been developed. The program includes inputs from farmers on variety, soil, and heading date. The results from the program are predicted dates for successive reproductive rice growth stages, water use during each stage, and a predicted stage of development for draining, which will allow the field to be drained. The water held in the soil at draining will allow the crop to develop to maturation without experiencing a yield- or quality-limiting water deficit.

The model has been tested for 3 years in the field against later draining control treatments. Yields have not been reduced for the treatments drained by the program compared to the control treatments in any year. Head rice yields have not been reduced in any year so far for the treatments drained by the computer program compared to later drained controls. (At the date of this report, the 2007 data for head rice yield were not complete for analysis.)

#### **Impact**

We find a usual minimum water savings of one less 3-inch irrigation. Water savings from one less 3-inch irrigation would be \$4.15 per acre for a water depth (depth to pump) of 50 feet. Water savings would be \$22.45 per acre for a water depth (depth to pump) of 300 feet. Other potential savings include reduced tillage costs due to harvesting in wet soil conditions and increased water availability for the soybean crop at critical stages of development. Moreover, earlier draining of rice fields could result in less depletion of aquifers.

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#### **Funding**

Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas Agricultural Experiment Station

### **Value-added fertilizer from broiler litter and biosolids**

#### **Issue**

Regions such as Northwest Arkansas, known for poultry production and rapidly growing municipalities, have a surplus of broiler litter and municipal biosolids. While these materials are excellent fertilizers, their production is increasingly viewed as a liability due to litigation between Arkansas and Oklahoma. These materials require reformulation from their natural state into products that are economically transportable from nutrient surplus regions to nutrient deficient regions.

### **Action**

Granulation, a new process cheaper than pelletization, was used in combination with litter, biosolids, urea, and various binding agents to produce a value-added granulated fertilizer.

### **Impact**

These materials were shown to be comparable to commercial fertilizer in transportability and had less impact on water quality than commonly used fertilizers

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Division of Agriculture, University of Arkansas

## **Grape phylloxera biology and control**

### **Issue**

Growers in the Ozark region are transitioning from juice and table grape cultivars to more wine grape cultivars that are not on grape phylloxera-resistant rootstocks. These hybrid cultivars have various amounts of *Vitis vinifera* parentage that makes vines more susceptible to both foliar and root forms of grape phylloxera. We need to assess these cultivars throughout the region to determine which have economically damaging levels of grape phylloxera on foliage that reduce yield or on roots that reduce health of vines (may kill vine). Several insecticides were recently registered for grape phylloxera on grapes. However, the decision-making for timing applications and insecticide efficacy against grape phylloxera has not been demonstrated in the region.

### **Action**

A best management practices program for grapes is being demonstrated in two vineyards in Arkansas and four in Missouri. Cultivars in vineyards in both states have been assessed for the number of shoots with grape phylloxera-galled foliage and the number of phylloxera-induced galls on the roots. Grape phylloxera crawlers were counted weekly in foliar galls and on tape traps on canes to determine the start and end of the crawler emergence period for each generation. One or two applications of several insecticides were evaluated in late spring for efficacy against grape phylloxera crawlers. Future research will determine if insecticides applied in early October will significantly reduce overwintering eggs laid on the vines.

### **Impact**

The grape best management practices program has been described to over 100 growers that have attended monthly summer meetings in vineyards in Arkansas and Missouri. Growers learn to monitor insect pests and make better decisions about the need for insecticides and how to improve the timing of each application. For example, we found that one

foliar application of insecticide at the initiation of the crawler emergence period gave equal control of phylloxera as two applications early and later in May. These recommendations will reduce insecticide usage and lead to better control of this significant pest of wine grapes in Arkansas and the region.

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Missouri Wine and Grape Board; Viticulture Consortium-East Grants Program; Cerexagri, Inc.; Bayer CropScience; Valent Inc.; Division of Agriculture, University of Arkansas

## **Mineral crystals as a natural plant defense against insects**

### **Issue**

Damage by chewing insects can lead to serious losses in virtually every crop plant. Plants defend themselves against chewing insects with both pre-formed defenses and some defenses that are induced by insect damage. The formation of pre-formed mineral crystals in leaves might enhance natural levels of resistance to insects.

### **Action**

The team is trying to understand how naturally formed calcium oxalate crystals in leaves of some plants are formed. Previous work by the team has shown that these crystals serve as an important part of defense against chewing insects. Recent findings are that the levels of calcium oxalate can be increased in soybean leaves by treating plants with calcium solutions. It remains to be determined if these changes lead to enhanced insect resistance. In addition, the team has initiated experiments to determine the effects of changes in calcium oxalate deposition on total gene expression. Researchers at the University of Arkansas Medical School are assisting in analysis of gene expression patterns.

### **Impact**

In spite of intensive efforts to control pests, significant losses in agricultural production are caused by insects. We have recently shown that we treat plants to cause a slight increase in the levels of defensive calcium oxalate. Our work with calcium oxalate crystals indicates that they are important in insect defense, and we might be able to utilize the genes responsible for this trait to produce plant varieties that are more resistant to herbivores. Understanding how these crystals are formed could lead to new strategies for selecting plants with altered levels, shapes, or localization of calcium oxalate crystals in crop species.

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## Knapweed biological control

#### Issue

Spotted knapweed (*Centaurea stoebe* ssp. *micranthos*, Asteraceae) is an exotic weed that has aggressively invaded numerous habitats in northern Arkansas over the past 10 years. The weed displaces desirable forage, dominates habitats, and makes invaded pastures less valuable, as cattle avoid feeding on the weed. Spotted knapweed populations have been confirmed in 19 Arkansas counties and our surveys identified pastures in Baxter, Carroll, Fulton, Madison, and Washington counties with knapweed. Knapweed is managed economically and ecologically using biological control agents (insects that attack knapweed) in northern states. Our goal is to implement a biological control program in Arkansas to reduce spotted knapweed in the state. However, agents that provide the greatest level of control vary among northern states, indicating that some species may have a better ecological match with a particular release location. There are no active spotted knapweed biological control programs in the South.

#### Action

The logical first steps were to determine which, if any, knapweed biological control agents already occur in the state and then determine if they are providing control. Surveys conducted across the state revealed only one biological control agent for knapweed occurs in Arkansas—a seed-feeding fly, *Urophora quadrifasciata*. The fly was discovered at all knapweed sites sampled. We also conducted experiments during the season to determine the impact of the fly on seed production of knapweed in Arkansas. No such studies had been conducted with this insect in isolation, as multiple biological control agents co-occur wherever this fly has been evaluated.

#### Impact

The biology of the fly is distinctly different in the southern U.S. Three generations of the fly occur here, whereas a maximum of 2 generations have been reported elsewhere. The fly significantly reduced the number of knapweed seeds produced. The impact of the fly was greatest when knapweed was environmentally stressed later in the season (August) relative to when the plant is most vigorous and producing its greatest amount of seed (July); in July, seed reduction was not significant. Production of apparently viable knapweed seeds was reduced by nearly 50% during the late summer. However, most viable seeds are produced earlier in the summer, a time when the fly did not impact

seed production. These data suggest it is unlikely that the fly alone will suppress knapweed sufficiently in infested areas, or stop its spread in the southern U.S. Thus, we will initiate a program to introduce additional biological control agent(s) from nearby states. This sequential approach best minimizes unnecessary movement of species, while still providing sufficient control to reduce herbicide use for this expanding noxious weed.

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USDA-APHIS-PPQ Cooperative Agreement; Division of Agriculture, University of Arkansas

## Forest management and riparian functions within shortleaf pine-hardwood stands in the Ouachita Mountains

#### Issue

Streamside management zones (SMZs) in the Ouachita Mountains of Arkansas and Oklahoma are frequently established along headwater ephemeral and intermittent streams to protect water quality. Although these riparian corridors represent 10-15% of a typical upland shortleaf pine-hardwood stand in this region, little is known about what other ecological functions these corridors may provide. The SMZs in this region are typically narrow and have high edge-to-interior forest ratios. As a result, stand management outside the SMZs, such as harvesting, could alter the structure and function of these riparian corridors. Land managers need a better understanding of the forest composition and structure of these riparian corridors as well as the impact of forest management on the ecological services provided by these corridors.

#### Action

Scientists from the Arkansas Forest Resources Center and Southern Research Station initiated a study to characterize the forests that occur in these SMZs and to determine the changes in their structure and function with different reproductive cutting methods that occur outside the SMZs. Forest composition, tree density, woody debris volume, snag density, and windthrow density were measured within SMZs located in mature, uncut shortleaf pine-hardwood stands, clearcut stands, and stands that received a shelterwood harvest. This information was also collected within the upland portions of the uncut shortleaf pine-hardwood stands.

#### Impact

Although riparian forests in the SMZs had slightly higher densities and more hardwood trees than the upland portions of the uncut shortleaf pine-hardwood stands, species composition was similar. Thus, corridors did not significantly increase tree species diversity or hard mast production in these stands. Harvesting, which removed the majority of



the trees in the upland portions of the stand, was found to decrease snag densities and increase windthrow within these riparian corridors. Reductions of snags may reduce the use of these riparian forests as refugia for cavity-dwelling wildlife, such as flying squirrels, following harvesting.

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#### Funding

USDA Southern Research Station; Arkansas Forest Resources Center; Division of Agriculture, University of Arkansas

## Monitoring bollworm populations for susceptibility to Bt toxins in Bt cottons

#### Issue

The U.S. EPA requires monitoring resistance in pest species targeted by transgenic insecticidal crops. Detecting shifts in susceptibility and understanding the genetic and ecological factors influencing resistance evolution will allow combating resistance levels and designing approaches to preserve the technology. Since 2002, we have conducted bioassays to track Bt resistance levels in bollworm, *Helicoverpa zea*, a pest of cotton and corn. In 2006, we began monitoring bollworm populations, based on our data and previous work at Mississippi State University.

Until recently, Cry1Ac was the only insecticidal protein available in Bt cotton. More recent Bt cottons express Cry2Ab and Cry1Ac toxins, Cry1Ac and Cry1F, or a non-Cry toxin, called Vip3A. The complexity of monitoring field populations for different insecticidal proteins and the need to understand how laboratory assay results mimic field selection are important challenges for managing resistance.

#### Action

Since 2002 we have established baseline responses of bollworm and tobacco budworm, *Heliothis virescens*, to Cry1Ac and Cry2Ab, by rearing field-collected insects from more than 250 populations across the U.S. and exposing the insects to Bt in various assays. The published results have become the standards for future field populations expected to be resistant to Cry1Ac and Cry2Ab. This past year we worked to establish similar benchmarks for Cry1F and Vip3A. We also began work to understand selection, using genetic material brought to our laboratory. Because our colonies originated from field populations, we have ecological information on the different collection sites to compare to observations of survival in the laboratory. The collective data studied across time and location will provide insight into field selection. Additional genetic studies are planned on preserved moths and correlation of data with our measured susceptibilities and ecological descriptors may provide insight into the genetic and biological factors governing

resistance evolution. Our expanding laboratory-field dataset will also allow us to examine fitness and possible fitness costs associated with varying levels of Bt susceptibility.

#### Impact

Our data for Cry1Ac illustrate tremendous variability in susceptibility of bollworm to the toxin. Scientists have recently discovered our data and conclude that resistance has evolved to the protein since deployment of Bt cotton in 1996. Although we agree that variability does not refute the evolution of resistance, closer examination of our dataset does not confirm a sustained or increased frequency of less susceptible types. This is a topic of debate and discussion in the entomological community, and our studies are now at the center of policy and strategic discussions of resistance management approaches.

From a more practical view, our dataset is the largest in the world. We hope that this base of information will stimulate additional research to understand the biology and ecology of this serious pest beyond the direct evolutionary response to Bt selection, and that our emphasis on studying field ecology of resistance evolution will be a model for future EPA regulations that have been based on theoretical models.

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#### Funding

Division of Agriculture, University of Arkansas Agricultural Experiment Station; U.S. EPA Biotechnology Risk Assessment Grant Program; USDA Cooperative Agreement, USDA-ARS SIMRU, Stoneville, Miss.; Monsanto Company, St. Louis, Mo.; Dow AgroSciences, Indianapolis, Ind.

## Monitoring of rivers for pesticides used in rice production

#### Issue

Pesticides aid in the production of food and fiber. However, there is also the potential for contamination of surfacewater. If environmentally harmful amounts of pesticides begin to appear in surfacewater, early awareness of the situation would make it easier to remedy.

#### Action

We are monitoring surfacewater at four locations each—on the Cache, St. Francis, L'Anguille rivers and Lagrue Bayou—every two weeks from late spring through August for pesticides used in rice production. These four rivers were chosen because they are small and are mostly in rice-producing areas, so there would be less dilution of any pesticide present from water from non-rice-producing areas. Some pesticides have been found at low parts per billion (ppb) levels during the growing season. The results for the past six years have been variable for some aspects, but con-

sistent for others. Originally molinate (Ordram) was one of the most frequently detected compounds, but the frequency declined and it is now not found. Now the most frequently detected compounds are quinclorac (Facet) and clomazone (Command). Concentrations are typically low (less than 10 ppb), but each year until recently we have found 1-3 instances where a compound was detected in the 30-50 ppb range. Most detections are in June and July, when compounds are applied. Over this time frame, we have seen no trends of increasing detections, concentrations, or multiple compounds in a sample. We have now established a baseline of what is found and what to expect in year-to-year variation. Analyses in future years will allow us to see if there are differences, either up or down.

#### **Impact**

It is not unusual to detect low levels of pesticides in surface water in an agricultural area especially during the growing season, since pesticides need some water solubility to be effective. We have not observed any trends toward increasing frequency, amounts of pesticides, or multiple detections in the rivers at the sites sampled in previous years. These results indicate that production practices as they are now being done in the rice-growing areas do not seem to be having an adverse effect on the surrounding water due to pesticide contamination.

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Arkansas Rice Research and Promotion Board; Division of Agriculture, University of Arkansas

## **Can precision agriculture technologies aid in increasing environmental stewardship of nematicides in cotton?**

#### **Issue**

Nematicides are the most widely used control measure in Arkansas and other cotton-producing states. Without the use of nematicides, growers could easily see a 15 to 25% reduction in yield in some fields. The two most commonly used nematicides for controlling *M. incognita* in cotton are aldicarb (Temik), a non-fumigant nematicide, and 1,3 dichloropropene (Telone II), a soil fumigant. Common drawbacks to routine use of a nematicide are the cost of material and the human hazards associated with their application.

#### **Action**

Evaluations of select precision agriculture technologies were conducted in 2005 and 2007 for increasing the awareness of yield loss resulting from nematode damage and effectiveness of current strategies using nematicides in cotton. Three site-specific nematode research projects throughout the state were chosen to represent the cotton-producing areas in Arkansas with historic yield loss from nematodes.

Nematode distributions were determined using GIS/GPS technologies and recommendations constructed utilizing current damage thresholds for Arkansas. Potential reduction in nematicide inputs and human exposure without sacrificing nematode control would be highly desired both environmentally and economically.

Results of the two-year study showed that accurate sampling techniques are vital to understanding how severe a nematode problem is in a select field. Utilization of more accurate sampling methods showed nematode distributions to be more non-uniform. This non-uniformity provided a good opportunity for site-specific application of nematicides (placement of pesticide only where needed). The two-year study indicated that a producer could reduce his nematicide inputs by an average of 30% without limiting his yield potential. A 30% reduction in nematicide inputs would be an estimated \$11.00 per acre. Statewide, growers treat about 200,000 acres annually; therefore, a potential 30% reduction over 200,000 acres would be about \$2.2 million in direct savings to the producers if precision agriculture technologies were adopted.

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#### **Funding**

Dow Chemical Company; USDA Natural Resources Conservation Service (NRCS) Conservation Innovation Grant; Division of Agriculture, University of Arkansas

## **Improving cotton fertility management practices in Arkansas**

#### **Issue**

Information on improved fertility recommendations and evaluation of potential benefits of poultry manure as a nutrient source will allow Arkansas farmers to use manure and fertilizers in an environmentally and agriculturally sound manner.

#### **Action**

Field experiments were conducted at three locations to study effects of poultry manure and nitrogen fertilizer on cotton. Both poultry manure and chemical fertilizer significantly increased the seedcotton yield. Seedcotton yields ranged from 699-2685 lb/acre for cotton receiving urea and 1519-2273 lb/acre for cotton receiving poultry manure. On average, cotton fertilized with urea produced greater overall yields. Application of >30 lb N/acre produced significantly higher yields than the no N control. In general, maximum seedcotton yields were produced with application of 120 lb N/acre.

#### **Impact**

These results suggest that poultry manure can be used to

supply some of the N requirement of a growing cotton crop. However, in order to obtain maximum economic yield, poultry manure should be combined with chemical nitrogen fertilizers. The outcome of this research will result in more efficient use of fertilizers and manure in Arkansas and will decrease the potential for water quality risks.

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#### **Funding**

USDA NRCS; Division of Agriculture, University of Arkansas

## **Improving nitrogen fertility management for corn production in Arkansas**

#### **Issue**

Arkansas corn production increased from 180,000 acres in 2000 to nearly 600,000 acres in 2007. Nitrogen fertilizer is one of the largest variable inputs in corn production. Increasing N use efficiency through fertility management practices that maintain high crop yields will increase growers' profit margins and reduce the risk of potential water quality problems.

#### **Action**

Field experiments were conducted at five locations to evaluate the effect of N fertilizer on corn and the potential for using a chlorophyll meter to determine the need for in-season application of N to corn.

#### **Impact**

Application of N significantly increased grain yield, leaf N concentration, and leaf chlorophyll content. Corn grain yield for the 0 N plots ranged from 31 to 179 bu/acre and 143-233 bu/acre for plots treated with 300 lb N/acre. Leaf N concentration for the 0 N plots was 1.62 to 2.87% and leaf N in plants from plots treated with 300 lb N/acre was 3.10 to 4.09%. In general, yield and leaf N concentration increased as the N application increased and maximum yield was produced by application of 240 to 300 lb N/acre. Relative chlorophyll meter reading was well correlated with relative corn yield and absolute and relative leaf nitrogen. These results indicate that a handheld chlorophyll meter can potentially be used to predict the need for in-season supplemental application of N. The information will be communicated to the growers, who might be interested in using a chlorophyll meter, and it will also be added to the database that we are currently developing for long-term evaluation of potential benefits of using a chlorophyll meter as a tool for environmentally sound N-fertilizer management strategies in corn production.

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Arkansas Corn and Grain Sorghum Promotion; Division of Agriculture, University of Arkansas

## **Soil-based test for nitrogen fertilizer management in rice**

#### **Issue**

Increasing nitrogen fertilizer prices threaten the long-term sustainability of U.S. rice production, and the development of a soil-based nitrogen test will result in better management of nitrogen fertilizer and more profitable rice production. Soil fertility has searched for a soil-based testing method to manage nitrogen fertilization in crop production for several decades. The current practice utilizes the rice variety, soil type, and previous crop to determine nitrogen fertilizer recommendations. This method has worked well on a regional basis, but with heightened environmental concerns and escalating nitrogen fertilizer prices, a more accurate method is required that can fine-tune the nitrogen fertilizer recommendation for an individual field. Current recommendations are based on variety, soil type, and previous crop and do not take into account the soil nitrogen that may become mineralized during the growing season, which can differ significantly from field to field even within a given soil type. Residual inorganic nitrogen in the form of nitrate has often been used to assess the nitrogen status of soil for corn production, but this method has limitations for rice production as there is very little residual inorganic nitrogen remaining in the soil within rice rotations. Any nitrate present prior to flooding may be lost due to denitrification after a permanent flood has been established. Understanding the amount of nitrogen that can be mineralized by the soil during the growing season may significantly reduce the amount of nitrogen fertilizer required to obtain maximum rice yields or at least optimize the nitrogen fertilizer applied to obtain maximum rice yields. Identification of a soil-based nitrogen test for rice production will allow more precise application of nitrogen fertilizers while utilizing native soil nitrogen and lowering potential environmental impacts due to excessive nitrogen application.

#### **Action**

A 3-year study involving laboratory and field trials has evaluated 3 analytical methods—an alkali diffusion technique, an alkali direct-steam distillation technique, and soil total nitrogen—for determining the nitrogen mineralization potential of a soil. Currently, 17 site-years of data have been collected within the state of Arkansas on silt loam soil including

2 sites that did not respond to nitrogen application. Results to date show a strong correlation ( $r^2=0.87$  to  $.89$ ) between percent relative grain yield and the nitrogen liberated with the alkali diffusion technique and alkali direct-steam distillation technique when the soil was sampled to the 18-inch depth. The coefficients of determination increased for percent relative grain yield and nitrogen rate to give 95% relative grain yield as depth increased until 18 inches, but then dropped significantly at the 24-inch depth. The predictive value of the soil's total nitrogen content for use in N fertilizer application also increased with depth but did not result in coefficients of determination as high as either the alkali diffusion technique or the alkali direct-steam distillation technique. These results suggest that sampling depth can play a major role in a soil test's ability to predict potentially mineralizable soil N and its ability to predict agronomic factors such as grain yield. The plant's ability to access mineralized nitrogen plays an important role in the success of a soil-based nitrogen test and should be taken into consideration when determining sampling-depth protocol.

#### **Impact**

The new Rice Soil Nitrogen Test (RSNT) will enable more accurate nitrogen fertilizer rate recommendations for rice because it will allow the producer to make nitrogen fertilizer decisions on an individual field basis rather than relying on regional soil type basis. Implementation of the RSNT will enable the optimal use of nitrogen fertilizer leading to the most economical rice yield with minimal disease and lodging while lowering the potential impact of the nitrogen fertilizer to the surrounding environment.

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#### **Funding**

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## **Legume persistence research**

#### **Issue**

Livestock operations in Northwest Arkansas are under increased scrutiny due to water quality concerns and interest in environmental stewardship. The possibility of sanctioning poultry litter application leaves many producers with few alternatives to using expensive synthetic fertilizer to cover plant nitrogen requirements. Our objectives were to investigate the persistence of legume species to potentially offset N

fertilizer and thus reduce external farm inputs.

#### **Action**

In October 2007, approximately 30 acres of existing bermudagrass pasture were over-seeded with various cool-season annual and perennial legume species. These species included red clover, white clover, alfalfa, kura clover, arrowleaf clover, crimson clover, hairy vetch, and subterranean clover. Seeding rates were based on University of Arkansas Extension Service recommendations and seeds were planted at approximately 1/2-inch depth at a 7-inch row spacing using a no-till drill. The experimental plots will be rotationally grazed throughout the next three growing seasons.

#### **Impact**

The introduction of productive legume species may contribute to covering N-requirements for grass pastures in Arkansas. An initial assessment revealed that in this study, alfalfa, crimson clover, red clover, and hairy vetch were better established than the other species. Some legume species are able to fix nitrogen up to 200 lb/acre, thus contributing considerably to easing the financial burdens for producers. While the perennial species used in this study may provide N throughout the growing season, annual species could supply N early in the season when grass growth is needed for grazing and hay harvest alike.

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## **Off-stream watering alternatives for cattle**

#### **Issue**

Watering of beef cattle may include stream access and using ponds with standing water. However, concerns regarding water quality and cattle health necessitate new approaches to on-farm cattle watering. The objective of this extension program is to provide producers with information on alternative watering systems and devices that increase cattle health and reduce environmental impacts.

#### **Action**

During a two-year period, field days will be held to inform producers and policy makers regarding novel and diverse watering systems for cattle. These systems include a solar-powered well, concrete spillways, and construction of pipes that channel water to troughs. Educational materials will be developed including fact sheets and a DVD comprised of materials that should help producers to set up new watering systems on their properties. Video footage will be recorded during the project period that encompasses inter-



views with participants, field day visitors, and extension personnel. This information will also be made available to county agents and other interested groups in the state.

### **Impact**

Providing alternative watering systems for cattle could reduce negative impacts on stream water quality and cattle health. Previous research has shown that by providing off-stream watering devices, the time of cattle standing in streams could be reduced by up to 80%. With this program, producers could participate in direct demonstrations while the production of a DVD will provide the same information to county agents in the State of Arkansas.

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### **Funding**

Division of Agriculture, University of Arkansas; Associate Vice President's Internal Grants Program

## **Identifying best management practices that reduce pollution and risk**

### **Issue**

Agriculture is a primary stimulus of economic growth in the Arkansas Delta. However, large acreages of rice and soybean employ high levels of fertilizers, pesticides, and water for production. Without proper management, use of these inputs could lead to sediment and nutrient movement off the farm and into nearby rivers and streams, further exacerbating water quality issues that already exist in the region.

### **Action**

A stochastic simulation model of a combination of 54 best management practices (BMPs) scenarios including 2 levels of tillage, 3 fertilization rates, and 3 filter-strip widths was used to address total phosphorous (TP) loading in the L'Angeuille Watershed in Arkansas. The purpose of this study was to identify the efficient set of BMPs in terms of its effectiveness to reduce TP and its relative costs to rice and soybean producers. Scenarios were ranked in terms of their relative cost-effectiveness of reducing TP per dollar spent, using stochastic efficiency techniques under a wide range of risk aversion levels. Results suggested that 5 BMP combinations consistently out rank all others, regardless of sub-basin size or amount of land devoted to agriculture in the sub-basin. Scenario 10 (rice conservation-till, soybeans no-till, low level of phosphorous (P) fertilization for both crops, and a filter strip of 5 meters wide for soybeans) was the most preferred regardless of the decision maker's risk preferences.

### **Impact**

The economy of the Arkansas Delta region relies greatly upon production of row crops. Few studies have analyzed

crop revenue risk in the State of Arkansas but no one has specifically addressed the issue of cost-risk incurred by producers when implementing BMP practices as a possible solution to water degradation. However, it is important to highlight that the effectiveness of BMPs should be rated not only in terms of their impact on pollutant loads but also by their acceptability to producers. Considering this last point, this study aims to enhance the body of water conservation literature by evaluating the risk faced by crop producers when they need to deal with the joint effects of water regulations and the cost of implementing BMPs in their farm operations.

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## **Soybean yield is not linearly related to water used**

### **Issue**

Previous research indicates that soybean yield is linearly related to the cumulative amount of water transpired by the crop during the season, indicating that restricting water use would result in proportional decreases in yield.

### **Action**

We conducted experiments under fully irrigated conditions using soybean varieties differing in the duration of their life cycle, which resulted in large differences in the total amount of water used by the crop during a season. Our data clearly indicate that yield is not linearly related to the total amount of water used during the season but reaches an asymptote, and further increases in water use do not affect yield.

### **Impact**

Water use in soybean can be decreased by approximately 200 mm by shortening the maturity from a full-season cultivar to a short-season cultivar without affecting yield. Increased efficiency of water use will likely be of increased importance as competition increases between agriculture and urban use and as the aquifer level decreases.

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Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas

## Urea persistence in a ponded silt-loam soil typical of rice fields in Arkansas

### Issue

Urea is a common fertilizer in delayed-flood rice production in eastern Arkansas. Arkansas grows nearly one-half of the rice produced in the U.S. Furthermore, the management of N fertilizer is one of the most important practices associated with profitable rice production. Not only is it critical to manage N fertilization to minimize losses from the production system, but low levels of urea have been implicated as an N source for algae in aquatic ecosystems, where excessive growth causes problems.

### Action

To address the potential of urea moving out of terrestrial systems and thereby contributing to harmful algal blooms, urea was analyzed directly by a colorimetric method in surfacewater and 10-cm length soil cores that were ponded for up to 96 hours. Dry and muddy soil was ponded immediately after urea application, and dry soil was ponded 5 days after untreated urea or Agrotain—urea treated with a urease inhibitor—application to the soil surface. N concentrations did decrease with increased ponding time, but urea was measured in the floodwater up to 96 hours if soil was ponded immediately after dissolving fertilizer. Urea concentrations were much higher if muddy soil was ponded. In contrast, little to no urea was measured in floodwater and soil if there was a 5-day delay between untreated urea application and ponding. Although not in the floodwater, urea-N was measured in soil when applied as Agrotain.

### Impact

It is important to make sure N fertilizer is applied and managed correctly. The movement of urea into soil upon initiation of a flood is critical to retaining N in the system. These data suggest that there is potential for urea remaining in floodwater to be a concern, especially if urea is applied to wet soil. The results of this research will be used to improve the management of N fertilization in rice production in eastern Arkansas.

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## Assessment of the impact of research evaluating herbicide drift to sensitive crops

### Issue

Modern intensive agriculture dictates that a variety of crops are grown in close proximity. Greater than 98% of all crops grown in Arkansas receive some herbicide for weed

control. Off-target movement of small amounts of herbicides from a tolerant species onto a sensitive crop can have devastating results. Grower decisions on what crops to grow and where are often dictated by very fluctuating commodity prices and input costs. This makes planning the placement of sensitive crops away from possible herbicide drift problems difficult. This problem is magnified by the diversity of crops grown in Arkansas and the fact that one grower has little input on what his neighbors may choose to produce in a given field. The effects of off-target drift on crops and production decisions that must be made following a drift event require special knowledge not readily available to all agricultural county agents and others.

### Action

Several studies centered around two masters students' thesis projects have been conducted over the past three years to evaluate the effects of off-target herbicide response in sensitive crops. These include: the drift of glyphosate (Roundup) onto rice or wheat; halosulfuron (Permit) herbicide drift to soybeans; 2,4-D, quinclorac (Facet), and halosulfuron on cotton; and glufosinate drift to soybeans, rice, and wheat. Data from these trials have been summarized and a pilot program entitled "Keep it in the Field" has been initiated. The purpose of "Keep it in the Field" is to increase grower and applicator awareness of the problem of herbicide drift in agriculture and to have a positive impact toward reducing the number of herbicide drift complaints filed at the Arkansas State Plant Board each year.

### Impact

Numerous field visits, county Extension meetings, training sessions, and one in-county pilot program (Lonoke) have been completed at this time. Although the program is only in its first year, the number of drift complaints to the Arkansas State Plant Board has decreased dramatically in 2007. This decrease is a result of greater awareness of the consequences associated with off-target drift as well as new regulations concerning application techniques. In addition, data are now available to help those involved understand the impact that herbicide drift may have on a given susceptible crop and the eventual effects on crop yield. Farmers and applicators better understand the characteristics of different herbicides as well as the impact that crop growth stage has on potential damage from herbicide drift.

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Division of Agriculture, University of Arkansas; Arkansas Soybean Promotion Board; Arkansas Rice Research and Promotion Board; Arkansas Wheat Promotion Board; various industry sponsors

## Improving the pesticide handling practices of Arkansas applicators

### Issue

The U.S. Environmental Protection Agency requires that all pesticide applicators that purchase or apply restricted-use pesticides must be certified and licensed on a recurring basis. In order to qualify for a pesticide license, an applicator must receive periodic training on the various aspects of pesticide safety and application, including human and environmental safety, labeling concerns, regulations, drift minimization, endangered species protection, ground- and surface-water protection, application equipment and calibration, and integrated pest management. The Cooperative Extension Service (CES) is the primary source for this training in Arkansas.

There are currently over 3,000 commercial/non-commercial applicators and over 17,000 private applicators in Arkansas that require the certification training provided by the CES. Private applicators are on a five-year training cycle and commercial/non-commercial applicators must be retrained every three years. All commercial/non-commercial applicators must pass a competency exam, administered by the Arkansas State Plant Board, before obtaining a license.

### Action

Certification training for pesticide applicators consists of in-depth training on the safe use of pesticides. The certification sessions conducted by Extension agents for private applicators consist of 2-3 hours of training. Each county in the state conducts 1-4 certification sessions each year. Agents use slide sets and videos developed by the Pesticide Safety Education Specialist for the training sessions.

The commercial/non-commercial applicators receive their certification training at 3-6 hour sessions conducted by the Pesticide Assessment Specialist. Approximately 18 of these sessions are conducted each year at various locations around the state. The Pesticide Safety Education Specialist provides most of the training, but Extension specialists are often included in the program to provide more specialized training.

The certification training for all pesticide applicators focuses on the safe use of pesticides. Topics include applicator safety, environmental safety, integrated pest management, application equipment and calibration, drift minimization, pesticide recordkeeping, the Worker Protection Standard, nitrogen management, and other issues related to pesticide application. Each applicator going through the certification process for the first time also receives a Pesticide Applicator Study Guide for future reference.

### Impact

The passing rate for the competency exams given to commercial/non-commercial applicators is well over 80%. This is in large part due to the training received at the certification sessions. In addition, the number of pesticide drift complaints received by the State Plant Board has trended downward since the CES began recertification training in 1990. Surveys of attendees of the certification training have

been periodically conducted to evaluate the sessions.

The last survey conducted indicated that out of approximately 1,600 applicators surveyed, approximately 50% had increased the use of integrated pest management on their farms and had changed their pesticide practices as a result of attending the certification sessions. An overwhelming majority of the respondents said they had increased their use of protective gear when applying pesticides, read the label more thoroughly, and generally took more precautions with their applications after attending the training sessions. The majority of respondents rated the certification sessions as good to excellent.

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The Arkansas State Plant Board

### Funding

User fees in the form of registration fees charged for certification/recertification meetings; The Arkansas State Plant Board; Division of Agriculture, University of Arkansas; Pass-through funds from the U.S. Environmental Protection Agency via the United States Department of Agriculture

## Control of honey bee pests and diseases

### Issue

The honey bee is arguably the most valuable of all insects. In the United States alone, the pollination value of the honey bee for crops is estimated at \$14 billion per year. The honey bee is under threat from many causes. In 2007, major losses of honey bee colonies were noted in the nation due to unknown causes, resulting in major media attention. In Arkansas, the major threat to beekeeping remains the varroa mite, a large, external parasitic mite of bees. Other threats to bees come from microbial pathogens such as viruses, microsporidia, bacteria, and fungi. Research on honey bees in Arkansas to help beekeepers control these threats is essential.

### Action

We continue conducting research on honey bee parasites and pathogens, and educating beekeepers. We are studying ecologically benign methods of controlling the varroa mite. Anecdotes in the literature suggest that botanical products, when turned into smoke, can knock mites off bees and help control them. We have tested many botanical materials for their effect in knocking mites off bees, such as red sumac, sassafras, pine needles, pixoy, and other materials. We are also dissecting and examining bees from around Arkansas for microsporidia and amoebae in their midguts and Malpighian tubules, respectively.

### Impact

Our outreach activities on educating beekeepers about the nutritional requirements for bees, and research on varroa mite control and prevalence of pathogens in bees, are bene-

fitting Arkansas beekeepers by providing scientific information on bees in Arkansas conditions. Our ongoing research on botanical smokes strongly suggests that botanical smokes have a minimal effect on reducing varroa mite problems. This finding is important because beekeepers may erroneously trust anecdotes from the literature and rely on smokes to control mites, when in fact smokes have little effect. Our data on prevalence of microsporidia suggest that this pathogen, which has been suggested as a cause of colony collapse disorder in honey bees, is not at all common in Arkansas and is unlikely to be the cause of colony collapse in Arkansas.

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Richard Coy and the Coy family, state beekeepers who submit research samples; Jon Zawislak, graduate student

#### Funding

Division of Agriculture, University of Arkansas Agricultural Experiment Station

## Cotton aphid natural enemy reduces pesticide use in cotton

### Issue

The cotton aphid is an important pest of U.S. cotton. Control of cotton aphids with pesticides is expensive, contaminates the environment, leads to aphid resistance and kills beneficial insects. In 1989, Arkansas researchers discovered widespread beneficial die-offs of cotton aphids caused by a natural fungus. Growers and scientists wondered how to use this fungus to benefit cotton growers. Arkansas entomologists studied the biology of this beneficial fungus and developed a program to utilize it in cotton Integrated Pest Management (IPM). This novel program, based in Arkansas with cooperators in seven states, utilizes this fungus by diagnosing levels in aphid populations from cotton fields in the seven-state area. Knowledge of natural control provided by the fungus permits growers to avoid unneeded insecticide applications.

### Action

In 2007, we operated (for the 15th year) the Extension-Based Aphid Fungus Sampling Service that predicts aphid declines in cotton due to a natural fungus. Cotton fields are carefully scouted by extension agents, growers, and consultants, who sample problem fields and mail aphid samples to the diagnostic laboratory in Arkansas. The aphids are examined under a microscope and diagnosed for presence of the beneficial fungus. The percentage of infected aphids is communicated to the sender within 24 hours. The information is also posted daily on an internet site, ([www.uark.edu/misc/aphid/](http://www.uark.edu/misc/aphid/)) where it can be accessed by cotton growers and extension agents. If infection levels are above 15%, an aphid decline is predicted and the field is usually not treated with an insecticide. This information is

used by growers to make IPM decisions in individual fields and also to track epizootic development across the states.

### Impact

Cotton growers have benefited from this service because it eliminates many insecticide applications for aphids, thus reducing production costs. We conservatively estimate that this service and the biological knowledge we have developed save cotton growers several million dollars a year. In addition, because insecticide applications are reduced, beneficial insects are preserved, the environment is less polluted, and aphid resistance to pesticides is delayed. This program is a classic example of IPM and has attracted national and international attention because of utilizing naturally occurring pathogens in IPM.

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### Funding

Cotton Incorporated; Division of Agriculture, University of Arkansas Agricultural Experiment Station

## Small mammal community associations on a wetland restoration site in southeast Arkansas

### Issue

The Wetlands Reserve Program (WRP) provides financial incentives and technical assistance for landowners to voluntarily restore frequently flooded, marginal agricultural properties to wetland conditions. Arkansas ranks second in the nation for the cumulative hectares enrolled in WRP (80,925 ha since 1992) and led the nation in hectares enrolled (6,697) in 2006. Commonly practiced on these lands is construction of shallow basins and associated mounds formed with the excavated fill. The topographic complexities associated with these features serve a variety of purposes, including the development of diverse water regimes, vegetative communities, and wildlife habitat. Our objective was to investigate small mammal communities associated with topographic and other habitat features that are characteristic of WRP properties in Arkansas. Small mammals are ecologically important for a multitude of reasons and play a vital role in the enhancement and preservation of biological diversity. Ecosystem services provided by small mammal communities include service as a primary prey base for several mammalian, avian, and reptilian predators; consumption of detrimental insects; and facilitation of the dispersal of fungal spores that form root-inhabiting ectomycorrhizae that are required by many plants for nutrient procurement, water absorption, and protection from root pathogens. In some circumstances, small mammals can impact the regeneration of plants through the consumption of seeds. A few species may also, through burrowing, influence hydrological processes.



### Action

The study was conducted on the Bob White Memorial Wetlands Research and Teaching Station (BWMW) located in the Mississippi Alluvial Flood Plain in Chicot County, Ark. The 148-hectare BWMW was enrolled as a permanent WRP easement in 2001 and was donated to the University of Arkansas at Monticello by the Bob White Foundation in 2006. Sherman live traps spaced 15 m apart were used in 4, 0.8-ha (7x7) trapping grids to sample small mammal communities. Each grid encompassed a complex of shallow basins and mounds. Trapping was conducted monthly in 5-d periods. Small mammal species captured at BWMW included the marsh rice rat (*Oryzomys palustris*), hispid cotton rat (*Sigmodon hispidus*), house mouse (*Mus musculus*), *Peromyscus* spp., fulvous harvest mouse (*Reithrodontomys fulvescens*), and the least shrew (*Cryptotis parva*). The hispid cotton rat and marsh rice rat comprised >80% of the individuals captured. Marsh rice rats were found at lower elevations, with house mice and *Peromyscus* spp. preferring higher elevations. Marsh rice rats were associated with water and cattails, presence of the fulvous harvest mouse was related to woody plants and vines, and the least shrew was associated with forbs and ground litter. Spatial distributions of small mammals as related to microhabitat characteristics were influenced by the complexity of the vegetative and physical environment associated with the basin and mound structures.

### Impact

Documentation of these species-habitat relationships provides increased insight into the effects of constructed basin-mound complexes on small-mammal community structure and composition. This increased understanding of interrelationships can aid natural resource managers in enhancing ecosystem services provided by small mammal communities associated with WRP management practices.

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### Funding

Arkansas Forest Resources Center, University of Arkansas at Monticello; Bob White Memorial Foundation; Division of Agriculture, University of Arkansas

## Selection of superior endophytes and tall fescue lines for improving resistance to drought and nematodes

### Issue

Tall fescue, a widely grown pasture grass in Arkansas, normally contains a fungus called an endophyte, which produces ergot-alkaloid toxins that reduce animal production and profitability. The endophyte also provides some degree of protection to the plant for drought tolerance and nematode resistance. Little is understood of the physiological and genetic mechanisms that explain the beneficial traits of such endophytes. Unlocking the mystery behind these mecha-

nisms would allow scientists to select endophytes that are both nontoxic to livestock and have superior drought-protection and pest-protection benefits.

### Action

A field trial was initiated in Northwest Arkansas in which tall fescue populations differing in summer-dormancy trait, and either with or without endophyte infection, were compared for drought survival and physiological traits pertaining to drought tolerance. Greenhouse trials were carried out to compare populations of Kentucky-31 tall fescue containing different strains of endophytes, which do not produce livestock toxins, for their ability to delay plant mortality due to drought.

### Impact

The field trial revealed that the summer-dormancy trait was more important than endophyte presence in ensuring tall fescue plant survival during summer drought. This indicates that endophyte-free varieties of tall fescue could be developed which support excellent cattle production if they possess a high degree of summer dormancy. The greenhouse screening trial identified nontoxic endophyte strains that showed particular promise in promoting tall fescue drought tolerance, equal to the toxic strain. The impact is that endophyte strains that do not induce livestock disorders can be selected for maintaining the persistence of summer-active tall fescue stands under conditions of drought stress. This new library of endophyte strains offers opportunities for promoting the sustainability of cattle, sheep, and horse production and health using low-cost, environmentally benign forage management systems.

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## **Arthropod Museum supports extension, research, and education missions**

### **Issue**

Over 60% of all known species are arthropods (insects, spiders, mites, crustaceans, and related groups), and they are the dominant form of life in terrestrial environments. There are perhaps 35,000 to 40,000 known species of arthropods recorded from Arkansas, and it is still not uncommon to find species here that are unnamed and new to the scientific world.

Pest arthropods cause harm to humans, structures, crops and livestock, whereas beneficial species pollinate crops, prey on pests, and serve as food for wildlife. Arthropods are regarded as essential components of our ecosystems. Unfortunately, most arthropods are not easily identified to species level by the general student, or even by trained specialists. Even the most-dedicated specialists find it difficult and sometimes impossible to identify some species they encounter.

### **Action**

The University of Arkansas Division of Agriculture Arthropod Museum houses the largest research and reference collection of insects and other arthropods in the State of Arkansas. The curator cares for the collection and makes efforts to increase the size and diversity of the collection so that it becomes ever more representative of the Arkansas fauna. The museum maintains one of the few large collections of the insect faunas of the Ozark Plateau and Ouachita Highlands. Specimens in all groups of arthropods are identified using specialized techniques, equipment, and literature; they are therefore priceless reference resources for comparison with unknown specimens. Our literature collection facilitates timely identification of pests, beneficial species, and other species of concern. The curator provides identification and information services to extension personnel, researchers, and the general public. Specimens are loaned to researchers around the world. Auxiliary collections are maintained for demonstration and teaching purposes. A growing Web site is dedicated to assisting the museum in its extension, research, and education missions.

In 2006, we began the process of rearranging genera and species within families. We also started a long-term project to transfer alcohol-preserved specimens to more-permanent vials. Seven new popular articles were added to the *University of Arkansas Arthropod Note* series on the museum's Web site concerning bagworms, bed bugs, drugstore beetles, organ-pipe mud-daubers, garden fleahoppers, harlequin bugs, phlox plant bugs, foreign grain beetles, and red velvet ants.

### **Impact**

The museum serves as the major resource for arthropod identifications in the state. With the aid of specimens and associated literature, we provide hundreds of identifications and information services to researchers, government agencies, businesses and the general public. Each year, museum specimens are exhibited to more than 10,000 citizens. The museum Web site

[www.uark.edu/depts/entomolo/museum/museum.html](http://www.uark.edu/depts/entomolo/museum/museum.html) reaches out to researchers with a bibliography of Arkansas arthropod biodiversity, and to extension specialists and the general public with a series of illustrated popular articles on important and interesting regional species.

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Cooperator

Greg Holt, USDA-ARS, Lubbock, Texas

### **Funding**

Cotton Inc.; Division of Agriculture, University of Arkansas

## **Master Gardener communication skills training**

### **Issue**

Home Gardening is a growing commodity. A train-the-trainer approach via the Master Gardener program has been a huge success for several decades. Keeping these volunteers motivated and engaged is a challenge. Their support has greatly expanded the horticultural programs across the country. While the consumer horticulture program is strong, we need better communication skill sets to reach a broader audience.

### **Action**

The University of Arkansas Division of Agriculture will offer a new program to Master Gardener volunteers and agents dealing with communication skills. Particular training will be in writing, power point, photography, and editing. Training will benefit local county programs as well as impact the horticulture program at a statewide level.

### **Impact**

This effort will impact the state by strengthening our volunteers and our program. It will also enable counties to have better rapport with their local newspapers and other media outlets. With proper training, the volume of work should improve and increase.

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Cooperators

Texas A & M Extension Master Gardener program

### Funding

Fine Gardening; Arkansas Flower & Garden Show;  
University of Arkansas Cooperative Extension Service;  
Division of Agriculture, University of Arkansas

## Factors influencing borrower exits from the Farm Service Agency direct loan programs

### Issue

The Farm Service Agency (FSA) makes direct operating loans, farm ownership and emergency loans to family-size farmers and ranchers who cannot obtain commercial credit from a bank, cooperative Farm Credit System institution, or other lender due to gaps in the credit markets. FSA loans are often provided to targeted groups—socially disadvantaged farmers and beginning farmers. The FSA direct farm loan program is designed to provide credit to family-sized farms that cannot get credit from conventional sources at market rates and conditions despite having sufficient cash flow to repay and an ability to provide security to collateralize the loan. In administering the loans, FSA has a goal to minimize defaults and to hasten the time when borrowers can exit the direct loan program and move on to conventional credit sources. In essence, the direct loan programs are meant to be transitory and not a permanent source of credit for farm operators. This policy goal of moving borrowers from direct loans to conventional credit sources is reflected in the larger loan volume of the FSA guaranteed loan program in which FSA guarantees the loan principal up to 95% from a conventional lender. To better enhance the transition to conventional loan sources, analysis was undertaken to identify those factors that were key in motivating borrowers to exit the direct loan program.

### Action

FSA farm loan managers (FLM) were surveyed in November and December 2004 using a survey instrument designed by a team of University of Arkansas researchers. The FLMs went to borrower files to collect data on a systematic sample of loans made in fiscal years 1994–1996 in forty-eight states (excluding Hawaii and Alaska). There was a 90% response rate, which is excellent for this kind of survey. The survey was stratified so that there was good geographic, ethnic, and loan type representation. In addition, data were collected directly from FSA on whether the borrowers originating loans in 1994–1996 were still participating in direct loans as of the end of November 2004. The data were collected by a secure FSA intranet and then delivered to the University of Arkansas for cleaning and analysis. A multinomial logit was estimated with four possible outcomes: borrower was still active in FSA direct loan programs, borrower was still in farming using conventional credit sources or no

credit, borrower voluntarily left farming, or borrower left farming involuntarily (other than death). The variables influencing which of these outcomes was the most likely were demographic variables; loan type (operating, farm ownership or emergency loan) and whether the loan was in the socially disadvantaged or beginning farmer program; variables indicating number of existing direct loans when the observed loan was originated; and various financial variables.

### Impact

The data show that FSA direct loan borrowers do not simply pay back one loan and then originate another. Fifty-five percent of the unique borrowers in the survey had left the direct loan program by approximately nine years post-origination. Borrowers exited the FSA direct farm loan program for many reasons. Approximately 24% of the surveyed loans, originated in fiscal years 1994–1996 and terminated by November 30, 2004, had borrowers who left farming voluntarily for reasons other than retirement. A little more than half the loans had borrowers who left the FSA direct loan program and remained in farming. A relatively small group of farmers continued farming without any credit. Twelve percent of the loans were associated with borrowers who exited from farming involuntarily (other than death). The logit model implied that frequent direct loan borrowers were less likely to be among the exited borrowers, suggesting FSA might consider limiting the number of loans to a given borrower over time. Borrower financial strength at origination was also found to be important. High debt-asset ratios and lower net worth led to difficulties as did financial difficulties prior to origination. The beginning farmer loans were associated with borrowers who subsequently left farming voluntarily at a higher rate than non-beginning farmer loans. Socially disadvantaged loan borrowers were less likely to exit involuntarily. Borrowers with farm ownership (FO) loans were less likely to exit the loan program, perhaps suggesting that low interest rates associated with FO loans might encourage such behavior. The study reveals that the direct loan program furnishes transitional loans to financially marginal farmers. Most borrowers did not become long-term FSA clients. Increasing financial requirements might hasten the transition process but at the cost of excluding perhaps the most stressed borrowers.

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Cooperators

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### Funding

Cooperative State Research, Extension, and Education Service (CSREES) Award number 2004-39528-14478;  
Division of Agriculture, University of Arkansas



## Socio-economic analysis of in-migration from Latin America

### Issue

Rural areas of Arkansas and, more generally, the rural areas of the United States have experienced a dramatic in-migration of individuals from Mexico and Mesoamerica. While these in-migrants have provided valuable contributions to the rural areas, the full impact is not understood. The particular concern of the current research is to better understand the characteristics of these in-migrants as compared to those who have migrated to urban areas of the United States.

### Action

In order to better understand whether there are differences in human and social capital between rural and urban migrants, the current effort (with the assistance of NRI funding) has obtained data that document social and economic characteristics of the migrants, including such things as origin, educational levels, language capabilities, and legal status.

### Impact

Empirical models show a clearly discernable residential sorting taking place internal to the current migration stream from Mexico (and likely Mesoamerica). This sorting is between rural and urban destinations with those migrants with less human capital (education, etc.) choosing rural destinations.

### Contact

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### Funding

NRI; Division of Agriculture, University of Arkansas

## Land use effects on stream water quality

### Issue

The degradation of water resources throughout Arkansas is a critical environmental concern, as the quality of our streams, rivers, and reservoirs are vital to the natural beauty and tourism of our state, as well as, ultimately, the health of the Gulf of Mexico. The input of nutrients from anthropogenic sources into streams, rivers, and reservoirs can accelerate the natural process of eutrophication and impair water quality and the water bodies' designated beneficial uses. These issues must be addressed at the larger watershed scale and thus require evaluation across defined land-use gradients.

### Action

In order to properly manage and protect our water resources, we need to know where these nutrients come from, how they get to streams and lakes, and when most of these losses occur. It is also vital to know what happens to these nutrients, once they leave the edge of a field and enter a stream or river, in order to determine or even predict how receiving water bodies will be influenced. This will require a multidisciplinary understanding of soil–water–nutrient

interactions, fluvial channel processes, and internal lake or reservoir mechanisms that can influence water quality. Several projects are evaluating the changes in physical, chemical, and biological conditions of streams' draining catchments across a gradient of land uses (e.g., forest, pasture, and urban).

### Impact

These multidisciplinary approaches have been applied in targeted watersheds across northwest Arkansas (i.e., the Eucha–Spavinaw Basin, Illinois River Basin, and White River Basin). The contributions from nonpoint sources and municipal wastewater treatment plants to annual nutrient loads have been identified, and this allows farmers, cities, and watershed managers to better focus efforts to reduce nutrient inputs from the landscape and critical effluent discharges. Furthermore, we have an increased understanding of how fluvial channel and reservoir processes influence nutrient transport and can act as nutrient sources or sinks, which allows us to communicate to stakeholders the importance of these processes and potential nutrient sources when considering watershed management strategies that will influence a diverse and wide range of stakeholders within the watershed.

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### Funding

Division of Agriculture, University of Arkansas; USDA Agricultural Research Service; USDA CSREES Nutrient Science for Improved Watershed Management Program; U.S. Geological Survey State Water Resources Institute Research Program; cities of Fayetteville, Springdale, and Rogers

## Arkansas biodiesel research, demonstration, and education project

### Issue

A majority of all U.S. biodiesel is based on the methyl ester of soybean oil. Arkansas ranks among the top 10 states nationally in soybean production with an annual farm-gate crop value of approximately \$500 million. Thus, the widespread use of soy-based biodiesel should provide economic benefits to both farmers and to rural communities in Arkansas. The University of Arkansas can play a leadership role in evaluating and promoting the use of biodiesel while, at the same time, furthering the University's commitment to sustainability.

### Action

UA Agricultural Systems and Technology Management

faculty (AEED Dept.), UA Campus Facilities personnel, and the Arkansas Soybean Promotion Board are cooperating in an applied research, demonstration, and education project evaluating and publicizing biodiesel (B20) as an alternative fuel for compression-ignition (diesel) engines. Seventeen Kubota RTV900-GT 4WD utility vehicles, operated by UA Campus Facilities, are being used in the research and demonstration components of this 2-year project. In the research portion of the project, 9 vehicles were randomly assigned to be fueled with B20 and 8 to be fueled with petroleum diesel. The vehicles are being periodically tested to compare: fuel efficiency (l/h), fuel cost (\$/h), exhaust emissions (ppm), and engine wear. The demonstration component of the project focuses on the on-campus public visibility of the 17 project vehicles. This visibility has been enhanced through the development and use of an eye-catching sign prominently displayed on each vehicle. Vehicles were displayed at 5 UA home football games and project personnel were on hand to visit with the public about biodiesel. Project personnel have also developed materials for a 1-hour educational presentation on biodiesel as an alternative fuel for compression-ignition (diesel) engines.

#### **Impact**

This project will provide real-world, comparative data on engine performance, fuel efficiency, fuel costs, and exhaust emissions for compression-ignition engines fueled with B20. The project will also increase public awareness and knowledge of biodiesel.

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#### **Funding**

Arkansas Soybean Promotion Board; Division of Agriculture, University of Arkansas Agricultural Experiment Station

### **Horses serve as ambassadors for agriculture**

#### **Issue**

Unlike many other livestock species, the horse is widely accepted and embraced by urban and suburban Americans. According to the American Horse Council's surveys, the densest populations of horses are found surrounding cities and towns. Land and lots demand higher prices in areas where horses are an integral part of the plan. Proper care and management of horses requires preservation of open pasture, commonly referred to as "green space" by city planners. Most urban and suburban dwellers, (whether they are directly involved in the equine industry or not) value horses for their esthetic appeal and contribution to preservation of pastoral vistas. Close cohabitation with horses improves quality-of-life. Or, as more memorably stated by Will Rogers "the outside of a horse is good for the inside of man."

This close physical proximity and positive relationship with people from non-agricultural backgrounds affords a unique opportunity for the equine industry to act as a leader and ambassador for agricultural interests as a whole. Horses are being utilized to engage and involve a segment of the general population that would otherwise be oblivious, disinterested, or apathetic to issues affecting agriculture.

#### **Action**

To engage the general population in agricultural activities through use of the horse, the D.E. King Equine Program produces three major public events a year. The Razorback Roundup Horse and Livestock Auction has drawn 450 attendees two years in a row. The Royal Lipizzan Stallion Show has sold out the 750-seat P. Whitaker Arena 11 times in 4 years. The annual UA Horse Festival has drawn an average of 2,000 people each year it has been held.

#### **Impact**

All together, an estimated 22,250 people (most with non-agricultural backgrounds) have been our guests for the various horse events produced by the students in the program. Surveys show the audiences are favorably impressed with the events. Building a positive relationship with the public and acting as an ambassador for the Bumpers College and Department of Animal Science are major roles played by the D.E. King Equine Program.

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#### **Funding**

In the first five years of program development constituents have donated 63 horses. Through special events and direct monetary donations approximately \$587,337 in funding for the program has been raised; Division of Agriculture, University of Arkansas

### **Performance, efficiency, and NO<sub>x</sub> emissions of a compact diesel tractor fueled with D2, B20, and B100 under steady-state loads**

#### **Issue**

Biodiesel is a renewable fuel manufactured from vegetable oils, cooking greases and oils, or animal fats. More technically, biodiesel is defined as "a fuel comprised of mono-alkyl esters of long-chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM D6751" (NBB, 2007). One primary concern about the use of biodiesel is a reported increase in the tailpipe emission of oxides of nitrogen (NO<sub>x</sub>). Since NO<sub>x</sub> is an EPA-regulated pollutant that increases ground-level ozone concentrations, this reported increase has caused concerns about the widespread use of biodiesel, especially in urban areas. The U.S. Department of Energy has called for more widespread testing on a variety of recent engines and vehicles of all sizes in order to develop a fuller understanding of the effects of biodiesel on NO<sub>x</sub> emissions.

**Action**

A study was conducted to compare power take-off (pto) performance, fuel efficiency, and NOx emissions of a 23.9 kW compact utility tractor fueled with No. 2 petroleum diesel (D2); a 20% biodiesel blend (B20); and neat biodiesel (B100) under two load conditions. Three steady-state (1h) tests were conducted with each fuel under both light-load (governor's maximum) and heavy-load (peak torque) conditions (18 total tests). Under light-load, there were significant ( $p < .05$ ) differences between the fuels for pto torque and power ( $D2 > B20 > B100$ ) and pto-specific fuel consumption ( $D2 = B20 < B100$ ); there were no significant differences for pto-specific NOx emissions. Under heavy-load, there were significant differences ( $p < .05$ ) between B100 and the other two fuels for pto torque and power ( $D2 = B20 > B100$ ) and for pto-specific fuel consumption and NOx emissions ( $D2 = B20 < B100$ ). The results indicate that performance, fuel efficiency, and NOx emissions were similar when the tractor was fueled with either D2 or B20, especially under heavy load. Fueling with B100 resulted in significantly less pto power and torque and higher specific fuel consumption and NOx emissions under both load conditions.

**Impact**

This study adds to the body of knowledge concerning engine performance, fuel efficiency, and NOx emissions of compression-ignition engines fueled with biodiesel. These results indicated that D2 and B20 resulted in similar engine performance, efficiency, and NOx emissions.

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Division of Agriculture, University of Arkansas Agricultural Experiment Station; FutureFuel Chemical Company

**Population aging and intergenerational eldercare assistance****Issue**

Population aging is a nearly global phenomenon that will have profound consequences for most nations in the world. It is estimated that the proportion of the population of the U.S. comprised of persons 65 years old or older was about 12.3% in 2000. This proportion was expected to grow to 18.5% and to 21.1% by the years 2025 and 2050, respectively. Not surprisingly, demographers and economists have raised concerns about meeting both the well-being needs of older persons and economic growth needs in the context of a growing old-age dependency ratio. Discussions about challenges associated with the expected growth in old-age dependency ratios have led to increased discussions about how families provide assistance to older family members. Laws and policies based on filial responsibility are not new in the United States. For example, Supplemental Security

Income (SSI) benefits are reduced to beneficiaries who live with their adult children or who receive in-kind benefits from children, suggesting that family members are obligated to provide beneficiaries with assistance at no cost. Importantly, providing assistance to family members varies across geography, race, and socio-economic status. Whereas some families provide direct care to their older members, some family members purchase care in the marketplace, and some families provide no intergenerational assistance. For this research, the question, "how are families' decisions about providing intergenerational assistance related to the well-being of family members?"

**Action**

The research question has been approached from using multiple methods. First, using data from 7,556 adults 51-years old and older living in the United States who participated in the nationally representative Health and Retirement Study (HRS), the relationships between intergenerational monetary transfers and psychological and physical well-being was examined. These longitudinal data were used to examine these relationships across a period of 6 years. Multivariate models predicting well-being included predictor variables drawn from previous empirical and theoretical works and included indicators of age, socio-economic status, race, sex, and marital status. This study found that financial transfers were likely to flow away from family members with less need and toward family members with more need. However, these transfers of resources are not without a cost over time, evident in decreased well-being for persons providing resources with little gain for family members receiving resources.

**Impact**

Policies that attempt to support the well-being of older persons by shifting responsibilities for their well-being to adult children are often based on assumptions about culturally defined norms regarding filial obligations, as well as on assumptions that those obligations are strong motivating factors for individuals' behaviors. It is not clear, however, whether or not these assumptions about filial piety are widely held, or how these assumptions are related to filial intentions and behaviors. More importantly, however, this study brings into question the assumption that these transfers positively impact the well-being of older persons. However, this study found that the economic relationships between parents and their adult children remained strong. These findings are consistent with assertions that, although kinship is an important factor in how people construct intergenerational obligations, it is not clear that those transfers increase the well-being of family members. As competition for public resources increases, it is likely that family members will be increasingly relied on to provide financial and other kinds of assistance that seniors need. This study will provide information about how policy changes are likely to impact families and the well-being of family members.

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**Funding**

Division of Agriculture, University of Arkansas

**Micro/nanoscale bio/abio interfacing technology****Issue**

The biomaterials, including DNA, proteins, and cells, are well optimized through evolution, exhibiting unique recognition, transport, catalytic, and replication properties. Instead of reinventing the wheel, the integration of such pre-engineered biomaterials into nano systems would lead to the realization of the next generation of bio/abio hybrid engineered systems for applications ranging from MEMS/NEMS-based micro/nano fluidic systems to bioelectronic and biosensing systems. However, the major challenges for making this merger feasible are integration and interfacing of the micro- and nano-scale biological and abiological materials at similar scales. The successful development of interfacing techniques for their integration is imperative to overcome the challenges.

**Action**

Currently, we are in the process of developing a series of nano hybrid devices through stable and *controllable* interfaces between bio and abio materials at the nanoscale. These devices under investigation in the laboratory include (a) a nano flagellar motor-based AC dynamo (nFMD), (b) a nano flagellar motor-based TNT detection system (nFMTNT), (c) a DNA-based CNT wire (DNA/NTW) nanosensor, and (d) a photothermal diagnostic and therapeutic system using near-infrared responsive nanoparticles.

**Impact**

These projects are important steps towards realization of the bio/abio nanotechnology that bridges the sciences of biology, medicine, nano-materials, and MEMS/NEMS by pairing their advantages. The research has generated over 14 publications and presentations during the year 2007.

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**Funding**

National Science Foundation (NSF; award #: CMI-0709121, ECS-0401196, and CMS-0508435); National Research Initiative (NRI) of the USDA-CSREES (award #: 2005-35603-15902); Arkansas Biosciences Institute (ABI); Division of Agriculture, University of Arkansas

**Non-crosshybridizing DNA oligonucleotides for DNA-based nanotechnology and DNA computing****Issue**

When used to self-assemble nanostructures for biological, medical and electronic applications, if DNA oligonu-

cleotides can form unplanned duplexes (crosshybridizations), defects might result. Likewise, crosshybridizations can produce errors in the results of DNA computations. Thus, there is a need for libraries of oligonucleotides that minimize crosshybridization.

**Action**

In my laboratory, *in vitro* methods have been developed and verified to produce large libraries with thousands of DNA oligonucleotides that interfere minimally with each other. These libraries are being used to self-assemble complicated nanostructures, for molecular electronic, medical and sensor applications, with greater control of component location to overcome the fundamental physical limits.

**Impact**

The libraries of DNA oligonucleotides produced in our laboratory should be useful for a variety of biological, biomedical, and other applications, particularly as DNA oligonucleotide building blocks for DNA-based computers and nanotechnology. The research has generated over 12 publications and presentations during the year 2005.

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National Science Foundation (NSF; award #: award #: CMI-0709121, CCF-0523858, and CCF-0407218); Arkansas Biosciences Institute (ABI); Division of Agriculture, University of Arkansas

**Childcare quality from the perspective of the childcare professional****Issue**

A need exists to examine variables that are related to childcare quality from the perspective of the childcare professional.

**Action**

Four hundred-nineteen childcare professionals responded to a questionnaire regarding the extent to which they felt competent in various aspects of their work with children and parents of the children. Demographic data are being analyzed that will indicate relationships among educational levels, specific training in child development, years in childcare, benefits needed, and the degree of competency expressed by childcare professionals.

**Impact**

Results of the study will be beneficial in enabling stakeholders and policymakers to have an awareness of ways to enhance opportunities for childcare professionals to facilitate greater quality in childcare.



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### Funding

Division of Agriculture, University of Arkansas Agricultural Experiment Station; Dale Bumpers College of Agricultural, Food and Life Sciences

## Adaptive management of the statewide nonpoint-source pollution plan for Arkansas

### Issue

Section 319 of the Clean Water Act requires that each state:

- Assess the waters of the state for impacts from non-point-source pollution;
- Develop a management program outlining how the state intends to address the categorical sources of pollution and the impaired waters identified in the assessment; and
- Report annually to the U.S. Environmental Protection Agency progress made in implementation of the program.

Arkansas' management program expired at the end of 2004. New state and federal regulations along with ever-changing environmental conditions in the state make it necessary to develop a major update of the current management program.

### Action

The Ecological Engineering Group developed an updated State Management Plan for 2005 through 2010, and used stakeholder-driven adaptive management strategies to revise and update the plan for 2008. The plan was approved in October 2006; it considers the impact of new regulations regarding urban and agricultural runoff, updated water quality information, and improved management measures developed over the last decade. The EEG used the Soil and Water Assessment Tool (SWAT) and ArcView GIS to model impaired watersheds in the state and to target specific nonpoint-source problem areas. An extensive consensus-building effort was conducted including facilitated meetings with all state and federal resource management agencies, local watershed action teams, agricultural commodity groups, and other non-government organizations. The results of the modeling and consensus building will be compiled into a single document that will be submitted by the Governor to the EPA on behalf of the State of Arkansas.

### Impact

The Nonpoint Source Management Plan establishes priorities for implementation of the section 319(H) Grant Program and gives guidance to all state and federal agencies in development of their environmental protection actions. In 2004, the section 319(h) program alone expended over \$6 million on nonpoint-source management. The consensus-

building program being conducted as an element of this project has brought together over 60 individuals representing 51 different agencies, NGOs, or watershed teams to discuss workable management actions concerning categorical and watershed-based programs. These management measures will be implemented in the State over the next 5 years.

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### Funding

U.S. Environmental Protection Agency; Arkansas Soil and Water Conservation Commission; Division of Agriculture, University of Arkansas

## Demonstration of a greenway development to protect ecological services in small urban streams

### Issue

The city of Rogers, Ark., is part of the rapidly growing metropolitan area of Northwest Arkansas. In 2003, this area was determined by the Milken Institute to be the best performing metropolitan area in terms of business development. The urbanization of historically agricultural land has stressed infrastructure to the limit. Alternatives to the current practices are needed to maintain more natural conditions in the area's streams.

### Action

A demonstration project on use of riparian corridors as greenway parks is being conducted by the City of Rogers, the UA's Department of Biological and Agricultural Engineering (BAEG), the Arkansas Water Resources Center, and Rogers Public Schools. A natural design is being provided to maintain ecological services in 4,900 feet of Blossom Branch Creek. The BAEG conducted analysis of the ecological services, hydrology, and geomorphology; designed a greenway park; supervised construction of the project; and is evaluating the results. Local and national technology transfer workshops have been held at the site for city planners, city engineers, and developers to adopt more sensitive drainage practices in their development plans.

### Impact

The City of Rogers, Ark., has adopted the Urban Greenway into its comprehensive-growth master plan for the city. The first phase of the greenway was dedicated in August 2006. Phase 2 of the project is under design by the BAEG. Plans are currently underway to connect this demonstration with an additional 23 miles of greenway, virtually encircling the city and connecting with the trail system of the City of Bentonville, Ark. As a result, ecological services of the headwater streams draining this rapidly expanding town will be retained and the impacts of the development will be significantly lessened.

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### Funding

U. S. Environmental Protection Agency and Arkansas Soil and Water Conservation Commission; Division of Agriculture, University of Arkansas

## Use attainability and water quality assessment of Coffee Creek, Mossy Lake, and the Ouachita River in southern Arkansas

### Issue

The Arkansas and Louisiana Departments of Environmental Quality have designated the Ouachita River to support the propagation of fish and wildlife; primary and secondary contact recreation; perennial Gulf Coast fisheries; and public, industrial, and agricultural water supply. Previous assessments in southeastern Arkansas have shown that water quality standards are not being met and have called for additional study in order to more accurately maintain these uses. Mossy Lake and Coffee Creek are used to treat effluent from Georgia-Pacific and the City of Crossett, Ark., before entering the Ouachita River. They flood approximately 60% of the year. It is unknown if Mossy Lake and Coffee Creek can support additional uses other than its designated industrial water supply.

### Action

The goal of this project is to perform a water quality assessment of the Ouachita River and to determine if aquatic life uses are attainable in Coffee Creek and Mossy Lake. In order to address previous data gaps, more complete assessment methods will be used. Data to be collected include: water quality field measurements, physical water conditions, analytical water analysis, sediment analysis, habitat assessment, and fish and macroinvertebrate community assessment. All sampling protocols will meet ADEQ requirements and ultra-clean metal-sampling methods will be employed.

### Impact

This project evaluated the current water quality status of the Ouachita River, Coffee Creek and Mossy Lake. This information will be used in better management practices in southeastern Arkansas and northeastern Louisiana. The final report was submitted in January 2007.

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### Funding

U. S. Environmental Protection Agency; Parsons Engineering; Division of Agriculture, University of Arkansas

## A watershed nutrient-management decision support system for the Eucha Basin

### Issue

A team of scientists in Arkansas and Oklahoma developed a watershed nutrient-management decision support system (DSS) to improve land use and water resource management decision-making. The project efforts focused on the Eucha Basin, with results applicable to similar watersheds across the U.S. The Eucha Basin was selected because nutrient management issues in this basin are representative of the political, economic, and ecological challenges facing resource managers across the U.S. The Eucha Basin includes Spavinaw Creek in northwestern Arkansas which drains into Lake Eucha in northeastern Oklahoma, a water supply reservoir for the city of Tulsa, Okla. Water quality in the reservoir has been declining for several years in part due to increased algal growth resulting from increased phosphorus loads from point and nonpoint sources, including the land application of poultry litter. However, there is no clear threshold for managing water quality for algal growth, so there is no clear management endpoint for phosphorus loading to the reservoir.

### Action

The goal of this project was to develop a nutrient-management decision and education support system (NMDESS) for developing comprehensive watershed nutrient-management strategies for both agricultural and urban landscapes. The process of *Analysis and Deliberation* was used to develop this DSS. This process involves intensive discourse, both in public education sessions and private interviews, between the scientific community, watershed managers, and other stakeholders within the basin. NMDESS provides a risk-based approach to identifying substantial nutrient sources within watersheds based on site-specific terrestrial, atmospheric, and hydrologic components of nitrogen and phosphorus nutrient cycles. NMDESS integrates risk-based decision-making theory with geographic information system (GIS)-based watershed modeling (Soil and Water Assessment Tool, or SWAT) and reservoir modeling (CEQUAL-W2) to create a decision support system that links land use practices with reservoir water quality.

### Impact

This project engages community members, educators, policy makers, and scientists from two states to develop NMDESS, a watershed-based ecosystem management framework. The NMDESS framework is unique in its integration of chemical and biological measurements, in-situ algal growth bioassessments, complex watershed and reservoir models, and stakeholder-developed scenario analyses. Land owners, policy makers, and other stakeholders will be able to

analyze the impacts of a wide range of land management scenarios on water quality in the Eucha Basin using this online tool. The methods and tools for implementing NMDESS are applicable nationwide.

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**Funding**

USDA-CSREES Watershed Science Program; Division of Agriculture, University of Arkansas

## **The Supersaturated Dissolved Oxygen (SDOX) and Ozone (HYDOZ) injector**

**Issue**

Proper treatment to remove pollutants from water affects all people of the world as well as many different industries. Humans require clean water to live and enjoy a good quality of life. Accordingly, governments regulate industries to ensure clean water in our shared environment is maintained. An indicator of the societal impact of wastewater treatment is that the U.S. market for bioremediation and wastewater treatment was \$9 billion in 2002. The predominant treatment of organic wastewater is biological, where bacteria digest organic matter through their respiration cycle. Efficient and effective biological wastewater treatment occurs under aerobic conditions (in the presence of oxygen) and therefore requires that oxygen be delivered to the water to meet the biochemical demands of the bacteria. If sufficient rates of oxygen delivery are not provided, the rate of treatment is greatly reduced and undesirable byproducts (such as odors) are produced. Another important tool for removing pollutants from water is the application of dissolved ozone. Ozone is a powerful oxidant that can kill bacteria, spores, cysts, and viruses. Ozone can also be used to oxidize chemicals to less harmful states. The use of ozone is becoming more and more important as the byproducts from chlorine disinfection (a competing technology) are becoming regulated as more is learned about their harmful effects on humans. Ozone also has potential as a technique for removing drug and antibiotic residuals from wastewater streams being released from hospitals. This treatment can reduce the occurrence of drug-resistant strains of bacteria that form because of exposure to residuals in the environment. Specific problems being addressed include: stream restoration, animal waste-lagoon odor prevention, removal of antibiotic residuals from hospital wastewater, drinking water treatment, municipal wastewater treatment, aquaculture, and food-processing wastewater treatment.

**Action**

The device developed utilizes a new technology that allows for the efficient oxygenation and ozonation of a wide variety of water bodies, both natural and manmade. This new technology is much less expensive to operate than existing technology for several key applications. Operating cost

savings of 80% have been demonstrated on-site at commercial operations. The patented and patent-pending technology delivers a stream of water that has been supersaturated with a gas (such as oxygen, air, or ozone). Once this supersaturated stream is released to a water body, the dissolved gas is blended with environmental waters and does not exit solution. The delivery of dissolved oxygen can be used to enhance the treatment of organic waste from a variety of sources (municipal and industrial wastewater treatment facilities, animal waste lagoons, aquaculture facilities, food processing plants, and more) and quickly increases the dissolved oxygen (DO) content of the water body and will enhance any process that requires aerobic bacterial digestion of organic waste.

The intellectual property for this invention is owned by the University of Arkansas and licensed to BlueinGreen, LLC, a start-up company created as a partnership between the inventors, the UA, and a private Fayetteville-based company, Virtual Incubation, Inc.

**Impact**

The use of the SDOX technology for delivery of dissolved oxygen for a variety of applications has been studied in detail. Commercial demonstrations of the technology have been conducted at Noland Wastewater Treatment Plant in Fayetteville, Ark.; Rogers Pollution Control Facility; Lake Brittany in Bella Vista, Ark.; and Norfolk National Trout Hatchery at Norfolk Lake, Ark. Operating cost savings of 80% have been achieved at the commercial scale. The first commercial sale of the unit was made to the City of Fayetteville in 2007.

Since the SDOX delivers oxygen in the dissolved state, a substantial cost savings is realized because none of the oxygen is lost due to bubbling out of the top of the water column as is seen with fine-bubble diffusers that deliver oxygen in the gaseous state. The impact of this result is that wastewater treatment facilities may be able to increase their processing capacity without increasing costs or adding significant additional infrastructure. The SDOX may also be able to replace existing technology and provide substantial operating cost savings to wastewater treatment plants.

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**Funding**

National Science Foundation; National Institutes of Health; Division of Agriculture, University of Arkansas; Beaver Water District; Tulsa water utilities; private investors

## **Generation of recycling materials at multi-family dwellings**

**Issue**

As Northwest Arkansas continues to grow at a rapid pace, viable options for household waste disposal are

decreasing. Currently many of the cities, such as Fayetteville, offer a curbside recycling program for single-family households but these programs fail to capture recyclable materials that may be generated at the nearly 14,000 apartment units and other multifamily dwellings within that city alone.

#### **Action**

A full sampling of a Fayetteville apartment complex residents' disposal activities was studied over 4-8 week intervals during a two-year period. Using the City of Fayetteville's approved recyclables list, a complete inventory of recyclable items was quantified during the study period. The average, total recyclable generation rate ranged from 1.97 kg/person/wk to 2.77 kg/person/wk across the periods. Fifty-two percent of the average resident's generated weekly solid waste was recyclable—an amount that would likely have been noticeably higher had compostable materials been included under recyclable categories.

#### **Impact**

Cities looking to promote sustainability initiatives as well as to identify potential new sources of income generation may be interested in the development of multi-family dwelling recycling programs. However, such programs come with their own costs. Policy makers need empirical knowledge of the composition, variability, and generation rates of recyclables associated with the waste disposal behavior of such residents. This study offers some of the first such detailed information available to policy makers in Northwest Arkansas.

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#### **Funding**

Division of Agriculture, University of Arkansas

### **Starting a wholesale nursery: Diversification via alternative enterprises**

#### **Issue**

Producers of traditional row crops (e.g. rice, cotton, soybeans) in the Delta region of Arkansas are looking for agricultural alternatives to stabilize and potentially increase farm revenues. Ornamental horticulture is one of the fastest growing segments of agriculture in the United States. Nursery production in Arkansas, ranked at 32nd in the United States, is considered the sector with greatest growth potential. Access to major transportation lanes, reasonably priced agricultural land, labor, water, and other resources makes Arkansas a prime state for large-scale nursery production. According to a Cooperative Extension survey in 2003, 45% of woody plant material in Arkansas is imported from other states. Arkansas nursery products could also be exported to many states.

A majority of county agents are not technically trained

in horticulture and need assistance in handling horticultural issues. Existing ornamental horticulture businesses require training and exposure to new plants and production methods to stay competitive. Tremendous opportunities exist for new ornamental horticulture businesses in Arkansas but these businesses require training and technical assistance.

#### **Action**

Cooperative Extension Service programs are designed to focus efforts on enhancing current ornamental horticulture businesses and to start new businesses. CES programs are focusing their efforts in 4 primary areas:

- Extension programs provide technical training and support for new and existing ornamental horticulture businesses and county extension agents.
- Printed and Internet-based fact sheets and a quarterly newsletter are distributed to existing ornamental horticulture businesses.
- Web-based materials are being designed to support quick access to timely and intensive graphics-based information.
- A statewide plant evaluation program initiated in 1999 is designed to evaluate and help market 'new' plant material for the Arkansas market.

#### **Impact**

Cooperative efforts by a team of faculty and staff within the Cooperative Extension Service have helped the third largest rice producer in the Delta region transition from rice to wholesale nursery production. The farm, located in Harrisburg, has planted a total of 120 acres of ornamental trees since the spring of 2002 with an estimated wholesale value of \$2.5 million. This same team of University experts is also helping a former row-crop farmer in White County transition to ornamental shade tree production. In 2005, field nurseries started production in Clay and Jackson counties and container nurseries started production in Washington and Independence counties. An additional nursery started container production in Washington County in 2006.

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#### **Funding**

Arkansas Green Industry Association; Division of Agriculture, University of Arkansas; Arkansas Farm Bureau; Arkansas State Plant Board

### **On-site wastewater renovation**

#### **Issue**

Improperly treated household wastewater is a source of unpleasant odor and can transmit disease-causing organisms. It is a major problem for lot owners and developers who cannot find a suitable soil that can accommodate household wastewater treatment.

#### **Action**

It is known that water moves rapidly through macropores and that earthworms cause macropores. When water



moves rapidly through the soil it does not reside as long in the soil and thus renovation of the water is reduced. We investigated the distribution of earthworms around soil trenches used for wastewater renovation. We found earthworms are attracted (about a 6x increase) to the trenches. We also evaluated the movement of earthworms in columns with and without sand layers. Our data indicate the sand layers retard earthworm movement but did not prevent movement.

#### **Impact**

Our research will not have an immediate impact on the design and construction of soil wastewater treatment systems, but it will contribute to knowledge for groundwater quality. Thus, sand layers in the bottom of septic tank trenches can be expected to greatly reduce the number of macropores in that plane and according to other research, fill other existing macropores.

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Arkansas Water Resources Center; Division of Agriculture, University of Arkansas

## **Educating the Arkansas public about insects through the Insect Festival and the Arthropod Zoo**

#### **Issue**

Insects play an important role in the lives of Arkansans. For instance, honey bees are extremely valuable for pollination, honey and beeswax. Recently, Africanized honey bees entered Arkansas. Their highly defensive behavior could lead to increased stinging incidents with the public. Termites are major pests of human-built wooden structures. Arkansas crops and trees are attacked by a wide variety of pests. Educating the public about beneficial and injurious insects is of great value.

#### **Action**

In 1990, we initiated the Arthropod Zoo of Arkansas, consisting of live insects and arthropods, and the Insect Festival of Arkansas was initiated in 1993. This event brings together entomologists from all over Arkansas who prepare numerous insect-related exhibits and children's games. The most recent Insect Festival of Arkansas attracted about 3,000 children and adults. The festival educates school children and the general public about the importance of insects and other arthropods in our lives.

#### **Impact**

Each time the Insect Festival has been held, it has attracted about 3,000 people, meaning over 30,000 Arkansans and other visitors have been impacted by the Festival over the years. The Arthropod Zoo is used for numerous events and festivals. Both the festival and the zoo have had an enormous impact on educating youth and the general public about entomology and the role insects play in

human welfare.

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#### **Funding**

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## **Isolation and characterization of blood meals from bed bug, *Cimex lectularius***

#### **Issue**

The ability to identify individual human hosts based on analyses of blood recovered from blood-feeding insects is beneficial for both medical and forensic entomology. Bed bugs, *Cimex lectularius* L., may have several advantages over other blood-feeding arthropods for forensics, because they do not remain on the host after their blood-feeding activity yet remain in close proximity to the crime scene. Successful isolation, amplification, and sequencing of human DNA obtained from adult bed bugs is reported for the first time from this study. Time course experiments can provide insight into how long bed bug bloodmeals may be detected by PCR.

#### **Action**

Engorged bed bugs were recovered from a human volunteer and from field-collected samples from New York, N.Y., and Brazos County, Texas. Bed bugs were allowed to feed on a human volunteer and were then frozen at intervals of 1, 3, 7, 14, 30, 60 and 90 d post-feeding. Samples were preserved by drying, stored in 70% ethanol, or freezing at -20°C. DNA was extracted from the individual insects and PCR was conducted using short tandem repeat (STR), human mitochondrial DNA (mtDNA) hypervariable region (HVR1), and insect mtDNA 16S markers. Bloodmeals could be detected by PCR up to 7 d post-feeding using the mtDNA marker and up to 60 d using the STR marker.

#### **Impact**

Amplification of a STR marker used in forensic investigations, D18S51, a HVR1 marker, and an insect mtDNA 16S marker was successful. The stability of human DNA in bed bug bloodmeals for up to 60 d reveals the utility of bed bugs for forensic investigations, and the time interval blood identification could be used to determine the time course of suspects in legal investigations. These results demonstrate that DNA isolated from bed bugs is qualitatively and quantitatively sufficient for DNA typing and could be helpful to identify individuals for forensic analysis and to identify the host range of bed bugs.

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#### **Funding**

Division of Agriculture, University of Arkansas

## Population genetics of the bed bug, *Cimex lectularius*

### Issue

Understanding genetic variation among populations of medically significant pest insects is important in studying insecticide resistance and insect dispersal. The bed bug, *Cimex lectularius* L., is a widespread blood-feeding insect pest found throughout the world, including North America, and has recently been identified as an emerging resurgent pest. To date, no studies have been conducted on genetic variation of this species.

### Action

We subjected 158 adult bed bugs representing 22 populations from 9 U.S. states, Canada, and Australia, to genetic analysis using PCR to amplify and sequence a region of the mitochondrial DNA (mtDNA) 16S rRNA gene and a portion of the nuclear rRNA internal transcribed spacer (ITS1) region. For the mtDNA, we identified 19 unique genetic lineages or haplotypes, as well as variation within many of the sampled populations. Three distinct mtDNA haplotypes were observed among the four Arkansas poultry facility samples, two of which also were found from human structures. Two distinct lineages were observed among the 19 mtDNA haplotypes. No genetic variation was observed in the ITS1 marker.

### Impact

High levels of mtDNA genetic variation suggest that bed bug populations did not undergo a genetic bottleneck, as one would expect from insecticide control during the 1940's and 1950's, but instead, populations may have been maintained on other hosts such as birds and bats. In contrast to the high amount of heterozygosity observed with the mitochondrial DNA marker, no genetic variation in nuclear genetic marker was observed. This suggests increased gene flow of previously isolated bed bug populations in the United States and, given the absence of barriers to gene flow, the spread of insecticide resistance may be rapid.

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### Funding

Division of Agriculture, University of Arkansas

## Women's methamphetamine use in a drug court sample

### Issue

Methamphetamine abuse is on the rise and considered to be one of the leading drug problems in the U.S. today. In general, illicit drugs tend to be used in greater numbers by men compared to women; however, methamphetamine is used in roughly equal proportions by both males and females, and is particularly on the rise by women of child-bearing age (Hohman et al., 2004). Also, women are more likely to use methamphetamine than cocaine. Regionally,

Missouri, Arkansas, Tennessee, and Oklahoma have some of the highest rates of methamphetamine drug use in the U.S., particularly in rural communities. Some of the social problems associated with methamphetamine abuse include increased crime, law enforcement and prison expenditures, mental health problems, domestic violence, child abuse and neglect, and drug-exposed children. A child growing up with a drug-using mother presents a significant risk factor for the child becoming a juvenile sex offender or facing incarceration as an adult. In addition, Arkansas has one of the highest child abuse rates in the U.S.

### Action

A grant was secured by the Northwest Arkansas Mental Health Association to do a pilot study of mental health problems and relationship violence among women in a drug court sample. Individuals in drug court are non-violent offenders, who have been evaluated as good candidates for treatment. The study is examining the women's mental health, drug use, history of family violence, and Post Traumatic Stress Disorder. Often, women drug users have a past history of child sexual abuse and domestic violence. Research on this project is in progress and utilizes an ecological framework to examine how women's substance abuse and mental health problems are determined by multiple risk factors related to a woman's personal history, family relationships, and community factors.

### Impact

Knowledge and understanding gained from this area of research can help to inform therapists, social workers, health care providers, policy makers, and the criminal justice system about factors that influence methamphetamine use from a more integrated ecological approach as it relates to individual, family, and community factors. In addition, family violence and child abuse are often root problems at the core of substance abuse (for both the women and their children). An outcome of this study is to help develop more effective interventions, treatment strategies, and community awareness to help combat methamphetamine abuse and family violence.

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### Funding

Northwest Arkansas Mental Health Association; Division of Agriculture, University of Arkansas

## Ants of some rare Arkansas habitats

### Issue

Little information is available for Arkansas on the ants inhabiting rare habitats. This study investigates the ants that live within several of them. Ants are among the dominant life forms on earth, comprising up to 15% of the entire animal biomass in many terrestrial environments, and they turn more soil than earthworms, and play leading roles in ecology

as predators and scavengers. The local diversity of ants usually exceeds most other animals because they typically saturate a wide range of feeding niches in the soil and vegetation. Ants can also drastically alter their physical environment, and in doing so affect many other species by moving soil, detritus, and seeds. This study should discover which species of ants are associated with these rare habitats. Such information can be used to help resource managers and policy makers better understand the value of these rare habitats as they relate to the maintenance of our state's biological diversity. In recent surveys of ant communities at Arkansas Post National Memorial near Dumas, Ark., and within the school forests of the University of Arkansas-Monticello, 1 new subfamily, 4 new genera, and 10 species new to Arkansas have been identified.

#### **Action**

Ants will be assessed in May and June 2008 using intensive sampling techniques at 5 rare habitats: Warren Prairie in Bradley and Drew Counties, White Cliffs Natural Area in Little River County, Nepheline-syenite glades in Saline County, Poison Springs State Forest Sand Barrens in Ouachita County, and the Saratoga Blackland Prairie Natural Area in Howard County. These habitats are managed by the State of Arkansas and/or The Nature Conservancy.

#### **Impact**

Assessing the potential benefits of the ant communities to these habitats can be accomplished only if one knows the species and their relative abundances. Knowledge of which species occur in which habitats is fundamental to making informed land management decisions and in keeping these places as natural as possible. Knowing the nature of the ant communities can also provide an indication of the difficulty the exotic, imported red fire ant may have in colonizing these sites, if it has not already done so, and could be a key to understanding the potential negative effects of this pest ant on these habitats.

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#### **Funding**

Arkansas Forest Resources Center; Division of Agriculture, University of Arkansas

## **Economics of pre-harvest vineyard mechanization**

#### **Issue**

Forty years of research at the University of Arkansas culminated in the development of the Morris Oldridge (M-O) System for complete vineyard mechanization. A patent was

issued for the M-O System in 2002 and was licensed to OXBO International. A comprehensive examination of the economic consequences of this system under actual commercial conditions was needed to demonstrate the value of this research and to provide a better understanding of the potential of mechanization to increase the long-term profitability of grape production in the U.S.

#### **Action**

University of Arkansas Division of Agriculture scientists collaborated with a large commercial wine-grape vineyard that had adopted the M-O system on significant portions of its acreage. Over the past 3 years, several visits to this vineyard were made to gather the information necessary to estimate the costs of mechanizing several labor-intensive pre-harvest operations. The vineyard manager emphasized that the ability to more consistently meet yield targets was an important advantage of mechanization. Budgets were prepared to compare production costs under mechanized and traditional hand-farming systems, and an additional economic model was developed to assess the value of flexibility inherent in mechanization.

Results of this study show that mechanization significantly reduces labor costs. Depending on the trellising system, mechanization can save anywhere from \$273 to \$611 per acre in production costs. Results from the economic model indicate that the flexibility afforded through mechanization is also of substantial importance. Estimates range from roughly \$100 per acre to over \$400 per acre, depending on the trellising system, potential value of the grapes, and magnitude of yield risk.

#### **Impact**

Growers of premium wine grapes rely heavily on hand labor in vineyards. Scarcity of labor, increased costs of labor, and increased competition from producing regions overseas threaten the long-term competitiveness of the U.S. grape industry. Information generated under this project demonstrates that mechanization can play a crucial role in addressing these challenges and provides practical and timely information to growers who are considering the transition to mechanized farming systems.

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#### **Funding**

USDA/CSREES; Multiple industry grants; Stephen Vann, Plant Pathology (Urban); Division of Agriculture, University of Arkansas

## Urban plant pathologist in Arkansas

### Issue

Public exposure and recognition is of foremost importance for the urban plant pathologist position. The establishment of a single source of disease-related information for urban populations throughout the state will reinforce the genuine need. The scope of urban plant pathology in Arkansas is very diverse, involving native and introduced disease pests that can directly impact citizens of the state. These plant disease pests pose both direct and indirect threats to agricultural commodities of Arkansans. The urban plant pathology program focuses on education of homeowners, agriculturists, youth, the professional landscape, turf, and nursery industries. The plant health clinic, an arm of the overall plant pathology program, continues to be an integral portion of the Southern Plant Detection Network for plant pathogens that may pose a potential bio-terrorism threat. The clinic is the hub of reporting and identifying pathogenic agents to the Southern Regional Plant Disease Clinic in Florida. Clinic records were routinely sent electronically through the regional headquarters at the University of Florida-Gainesville campus. Plans to link other diagnostic facilities (nematode diagnostic lab and entomology lab) are underway.

### Action

Program goals are achieved through county and state educational programs such as demonstrations, applied research, education booths, presentations, publications, newsletters, Web pages, in-service training of county faculty, and news releases.

A Plant Disease Clinic Web page is available on the University of Arkansas Extension Web site. Recent additions include a digital image library outlining and displaying more than 150 high-quality images of various diseases on fruit, turf, ornamental, and vegetable crops. This library will serve as a helpful tool in aiding in the identification of significant disease that may impact Arkansas agriculture.

Over 60 digital images of plant diseases/disorders were received for consult by email. This is a definite indicator of awareness among all growers. Spring Tune-up (award nomination) was developed to serve greenhouses and nurseries with disease ID and control.

The "Pest Guys" Web page was developed for the Extension Web site (2007) to allow the opportunity for growers, et al. to submit questions to a plant pathologist specialist, entomologist, or weed specialist. The Web page appeared in Oct. 2007 and will be re-introduced in spring 2008.

### Impact

The activities of the urban plant pathology program are specific to Arkansas and its agricultural components. Plant disease education programs are presented to all interested counties that have an agricultural sector. The urban plant pathology program is aimed to connect and help the citizens of Arkansas and agriculture through service and education on those topics relating to plant diseases.

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### Funding

Division of Agriculture, University of Arkansas

## Biodegradation of selected nonwovens

### Issue

With sales of nonwoven products in North America reaching \$4.97 billion in 2005, and the industry forecast to continue to grow by more than 4% a year, the nonwovens market is expected to exceed \$6 billion by the end of 2010. According to the 2006 INDA analysis report, North American roll goods producers shipped 2 billion square meters of nonwoven fabrics in 2005, equivalent to 1.25 million tons, for domestic consumption and exported about 285,000 tons of nonwoven material, with a value of \$1.3 billion. What happens to these products/materials/fabrics? Many are dumped into landfills; therefore, they should be degradable, be able to undergo accelerated change, and not have an adverse effect on the environment.

### Action

The purpose of this study was to determine the utilization of soil burial as a means of acquiring answers to the biodegradability of nonwovens being deposited into landfills. Emphasis was placed on strength characteristics, colorimeter analyses, and polarized light microscopy. Six nonwovens, representative of recycled melt blown PET webs of two different weights, polypropylene melt blown and spunbonded webs, and cotton/polypropylene thermally bonded specimens, were selected for experimental purposes. Red Clay (pH=4.8) and Calloway Silt Loam (pH=7.5) soil types were used for burial in compartmentalized plastic boxes. Each filled container was placed in a controlled environment room and monitored every 2 weeks with water being added to the soil surface to provide the same moisture content and weight. Fabrics remained buried for 2, 4, 8, 16, 32, and 64 weeks. Colorimeter and breaking strength data were collected initially and following each of the 6 burial periods. Polarized-light microscope slides were taken to assess surface degradation, fiber fibrillation, crusting of soil, and/or disintegration of specific fiber contents.

Visual observation of the test specimens following the different burial periods indicated that each one was becoming darker in color. Fungi and molds could be seen on the specimen surfaces, especially those containing the cotton core layer. Colorimeter analyses confirmed these observations. The polypropylene spunbonded nonwovens were the strongest fabrics throughout the study. Disintegration of the cotton core layer in the blended nonwovens created strength loss after two weeks of burial. The melt blown polypropylene nonwovens were weak in the beginning of the study and continued with this attribute until the end. Because of the filament fibrillations and cracks seen under the polarized-



light microscope after four weeks of burial, this study supports the theory that embrittlement of polypropylene occurs progressively during soil burial activities.

#### **Impact**

Soil burial has been proven to be an effective method to determine the biodegradation of (selected) nonwovens. If increased utilization of nonwovens in disposable goods is to continue, studies reflecting *real life* landfill simulations will be necessary. When comparing the two soil types, acidic versus nonacidic, it was the nonacidic Calloway Silt Loam that caused the greatest amount of physical degradation. The type of soil used in future landfill sites may need to be analyzed more carefully. Nonwovens containing cotton proved to be more susceptible to biodegradation than were the recycled polyester- or polypropylene-containing webs. Cotton is environmentally friendly, but it also gives high tensile strength, exceptional absorbency, efficient wicking, resistance to static electricity, and good processing features. Because of these attributes, cotton should be utilized more effectively within the nonwovens industry.

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#### **Funding**

Division of Agriculture, University of Arkansas; Industry

### **Arkansas housing and health survey: Achieving a person-environment fit**

#### **Issue**

The healthcare and housing industries are the two largest economic forces and have the most extensive social and financial impacts on individuals and families in the United States. The current support system, in terms of housing and healthcare for older adults and people with disabilities, relies heavily on nursing home care and various forms of assisted living. This type of living environment is problematic for two reasons: cost and perceived quality of life. Nursing home care is more than double that of in-home care; nursing home care costs the federal government more than \$150 billion annually.

#### **Action**

The purpose of research is to better understand the fit between the person and the built environment and, more specifically, the individual and his or her home. Each of us has a unique set of variables that include things such as age, gender, abilities and disabilities, culture, geographic origin, past experiences and living environments. Preferable to most individuals, the idea of living at home through the lifespan embodies a quality of life achievable in no other environment.

Investigators conducted the Arkansas Housing and Health Survey to examine housing preference and perceived health status across the state. The results indicate that while the overwhelming majority of Arkansans wish to live at

home throughout their lives, they understand that they will experience significant decline in health during later life. At the same time, Arkansans do not believe the design of their homes will impact their ability to live independently. Investigators are preparing information to be disseminated across the state with several objectives. First, Arkansas policy makers, housing designers, and consumers must be educated on the impact housing design has on individuals' abilities to live independently. Second, housing designers and builders must be educated to a new standard that encompasses inclusive design for people of all ages and functionality. Finally, both design and construction must be re-visioned to respond to not only the physical and emotional needs of an individual but to provide housing that is accessible financially to all Arkansans.

#### **Impact**

Policy makers, housing designers, home builders, and consumers will be better informed as to the issues associated with creating equitable housing. Through the construction of housing that fulfills Arkansans' needs, state, federal and private funds can be shifted from costly nursing home care to provide basic preventative and healthcare for the state's residents.

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#### **Funding**

Arkansas Rehabilitation Services; Arkansas Dept. of Health & Human Services, Division of Aging and Adult Services, Centers for Medicare/Medicaid Services; UAMS, Partners for Inclusive Communities; Division of Agriculture, University of Arkansas

### **Assessing the spatial accuracy of Applanix DSS™ Model-301 Sensor for the collection of geographic information systems data**

#### **Issue**

During the past decade, Geographic Information Systems (GISs) have become widely used in many disciplines and that has created demand for accurate high-resolution digital data, especially digital imagery. Photogrammetry has emerged as one of the most important disciplines employed in the collection of spatially related information for use in GIS databases, especially for terrestrial landscapes. In the past, Geographic Information Systems (GISs) were primarily used as a descriptive tool, but now, GIS is also used as decision-making tool. Because these decisions directly affect the public, making sure that the highest quality data are used for decision-making may be the most important step in using GIS in the decision-making process. This study assessed the horizontal and vertical accuracy of the Applanix Digital

Sensor System (DSS™) 301 orthophotographs. Orthophotographs are one the most used data sets for digitizing features to use in a GIS.

#### **Action**

The study area was at the University of Arkansas at Monticello (UAM) and consisted of approximately 950 acres. The aerial images were taken at approximately 914.4 meters (3,000 feet) above the ground, producing a resolution of 15.24-cm (6-inch) square pixel. The 28 individual exposures were taken in natural color (RGB) in the morning on February 18, 2005. To assess the spatial accuracy of the DSS, 56 Ground Control Points (GCPs) were collected prior to image acquisition using Trimble Surveying grade 4700 Global Positioning Systems (GPS). The 28 stereo aerial photographs used to create the orthorectified mosaic were taken with the DSS™ 301, with approximately a 15.24-cm (6-inch) pixel spatial resolution. Three orthorectified mosaics were created in this study; method 1 used the DSS GPS-aided IMU, with no GCPs and the 30-meter United States Geological Survey (USGS) DEM; the second mosaic method used the DSS GPS-aided IMU with 1 GCP per image and the USGS 30-meter DEM; and the third mosaic method used DSS GPS-aided IMU with a 2-meter DEM created from the DSS's stereo pairs. The first and second mosaics allowed an assessment of accuracy differences between an orthorectification using no GCPs, with GPS-aided IMU; and the GPS-aided IMU, with 1 GCP per image. Method 3, which used DSS imagery processed with the GPS-aided Inertial Measurement Unit (IMU) information and the 2-meter DEM created from the DSS stereo imagery produced the most accurate orthorectified image mosaic in this study. The total Root Mean Square Error (RMSE) for this method was 0.186 meters with an east-west RMSE of 0.131 meters and a north-south RMSE of 0.132 meters.

#### **Impact**

Information on accuracy of GIS data is important since these data are used in the decision-making process and for modeling. Without an understanding of the horizontal accuracy of orthophotographs and the systems that create these data, we have no information on the spatial accuracy or variability of data created from the imagery. Many times the data are assumed true, which is not the case. This research helps us understand the accuracies of imagery collected with an Applanix Digital Sensor System (DSS™) 301.

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Arkansas Forest Resources Center, University of Arkansas at Monticello; Kingwood Forestry Services, Inc.; Division of Agriculture, University of Arkansas

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## Society-Ready Graduates

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### Biological engineering students design prosthetics for the developing world

#### Issue

In developing countries, there are many people who have suffered amputation of limbs due to trauma (from war and motor vehicle accidents) along with complications from diabetes and other vascular diseases. Physicians in many countries are less able to save threatened limbs due to poor emergency health care and almost non-existent follow-up care in the home. Prosthetic limbs typical in the U.S. are much too expensive for amputees in developing countries. Most patients either suffer without an artificial limb, or they rely on donated prosthetics (e.g., discarded by patients in the U.S.) imported to the country by international medical missions. In order for the medical systems in developing countries to meet needs of their patients in a sustainable way, there is a need for prosthetic components that can be manufactured locally in developing countries

#### Action

Two University of Arkansas biological engineering senior design teams focused in 2006-2007 on the design of low-cost prosthetic devices for use in developing countries. One team designed and implemented modifications to the International Red Cross arm to make it a more functional upper-extremity prosthesis. They added body-powered motion (shoulder flex, bicipital abduction) to flex the forearm. They designed a cable-operated locking mechanism for the elbow, which is activated by a shoulder drop movement. Both of these are simple mechanisms that can improve quality of life for the patient. A second team designed a low-cost, adjustable lower-limb prosthesis for children in developing countries. The two main portions of the prosthesis were the socket and pylon. The socket was created using a composite material constructed of sawdust and recycled high-density polyethylene, which are locally available worldwide. The pylon was constructed using two pieces of standard-sized structural aluminum tubing selected for a telescoping fit to allow easy adjustment of length as the child grows. Students did the research, considered multiple alternatives, and used engineering methods to optimize the best solutions. The second semester of the course sequence allowed students to build and test prototypes of their designs. A team of 5 students and 1 faculty presented ideas to a prosthetic clinic in the Dominican Republic.

#### Impact

Biological engineering students are learning to incorporate biology and engineering to solve problems in the medical field. Prototypes designed, fabricated, and tested by student design teams in their senior design course provide evi-

dence that graduates of the program will make contributions as professional engineers to improve medicine, health, and quality of life. One student project from the 2006-2007 academic year took top honors in the 2007 RESNA National Student Design Competition. The competition, sponsored by NSF, is intended to promote new technology to assist disabled persons. Students in Arkansas—who have an interest in engineering, biology, and serving people—have an accredited engineering program at the UA that will help them to develop into important players in the worldwide health care system. Graduates can go on to medical school, do graduate work in biomedical engineering, or seek industry jobs at the bachelor's level.

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College of Engineering; Division of Agriculture, University of Arkansas Dale Bumpers College of Agricultural, Food and Life Sciences

### Learning leadership practices through popular media

#### Issue

Leadership concepts are learned when applied in real situations. Many undergraduate students lack diverse, rich experiences that help them learn leadership practices. Simulations are great tools for helping students but due to classroom limitations may be difficult to achieve. Media clips are excellent teaching tools because students can observe and analyze situations. This method encourages students to move beyond Bloom's basic intellectual levels and understand leadership through analysis, synthesis, and evaluation.

#### Action

Media clips are being integrated into AFLS 3131H (Honors Leadership and Management) at the University of Arkansas. Media clips from marketed leadership videos, YouTube, and news outlets are used by instructors to introduce concepts, stimulate discussions, and provide students with situations for analysis, synthesis, and evaluation. Students also utilize media clips to plan and present brief lessons, thus assisting peers and demonstrating their depth of leadership knowledge.

#### Impact

Students are more engaged in learning and discussion when the media clips are used. Discussion is listed consistently as the best part of the course on the open commentaries. All of the students will engage in leadership roles

through their professional careers, and have learned leadership concepts in a context paralleling the situations they will encounter.

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## Incorporating reporting, news and feature writing, and multimedia into an agricultural communications course

#### Issue

As the field of agricultural communications continues to expand and broaden, graduates must become more diversified in their skill-sets and competencies. Technology is harder than ever to keep up with; however, it is the responsibility of higher education to observe and implement curriculum aligned with the changes and innovations in technology to prepare students with high-quality learning experiences. Technology is pervasive, leaving us almost helpless in today's society without knowledge about its uses. Communication media have changed the thoughts and ideas of people pertaining to agricultural fields. This influx of innovative technologies is changing the face of agricultural communications. Incorporating new technologies and media and providing experiences for students to utilize these mediums while maintaining the rigors of reporting, writing, and editing are a must in agricultural communications courses.

#### Action

Practical experience with journalistic interviewing, news writing, feature writing, digital photography, and writing for broadcast guided the AGED 401V (Ag Reporting and Feature Writing) course offered this past fall at the University of Arkansas. The course incorporated the World Wide Web, videography, and digital photography. Throughout the course, students had the opportunity to write for specific mediums including newspapers, magazines, radio, the Internet, and other current and emerging mediums (personal blogs and wikis) used to communicate with the agricultural industry and its stakeholders. Beyond the rigors of reporting, writing, and editing, the course provided students with an introduction to photography and video, including photo, video, and audio manipulation and editing. Students participated in agricultural reporting and individually wrote three news and two feature articles for mediums of their choice. Students learned about proper photography composition and created a photo portfolio that included 26 agricultural-related photographs with captions. Students participated in writing scripts and group video projects with the intention of creating short agricultural videos for YouTube.

#### Impact

Students are more engaged in learning and discussion when they are challenged with technology. Today's student is more technologically savvy when compared to the traditional instructor. They enjoy utilizing multiple mediums and are spurred in their creativity. Students are not apprehensive about new communication technologies, and often find new and more effective ways to complete tasks associated with electronic media. With blogs (personal publishing), photos, and videos growing exponentially on the Web, our students are not only prepared with sound interviewing, reporting, writing, and editing skills, they are also prepared to communicate using multiple electronic media formats.

As a direct result of this course, four students were given monetary rewards for photos that are highlighted in the 2008 *Agroknowledge* calendar, and three of our agricultural communications students secured freelance writing positions for the *Ozark Farm and Neighbor*. Agricultural communications students are now writing for the first edition of *Ag Wire*, the Agricultural and Extension Education Department's newsletter. There was a need to provide an area for students to record and edit high-quality audio and video to meet their publishing endeavors. In response to their need, the Agricultural and Extension Education Department created a multimedia sound recording and editing booth. We currently have more than fifteen students utilizing the facility to record and edit high-quality audio and video for publication and/or streaming. Interest has been expressed by agricultural communications students to design, shoot, and edit a recruitment video and a virtual tour of our faculties to stream from the Bumpers College Web site.

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#### Funding

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## Enhancing diversity at the University of Arkansas

#### Issue

Increasing the diversity of faculty and students is one of the five major goals for the University of Arkansas. The UA is striving to make the campus more diverse to foster a deeper understanding among minority students, faculty, and staff. The new UA diversity plan provides a comprehensive blueprint that creates a welcoming atmosphere for members of diverse population to our campus. Building a diverse community of students, faculty, and staff will help the UA to reach its full potential. The chancellor, the provost, and the deans of the Dale Bumpers College of Agricultural, Food and Life Sciences are making several efforts to increase the number of underrepresented minority students.

One of the successful programs that has attracted academically superior minority students to the university is one that provides hands-on research opportunities for summer



interns, coupled with faculty coaching and mentoring. Graduates from this summer internship program are motivated to continue their graduate science education.

#### **Action**

A member of the UA Food Science faculty, together with the Diversity Committee of the Institute of Food Technologists (IFT), worked cooperatively to write a grant proposal to MasterFoods USA. They were funded \$80,000 to recruit 4 underrepresented minority summer internship scholars per year for 3 years starting in 2003. A Nationwide search followed with a final selection committee made up of faculty from the Department of Food Science. Four faculty and 4 scholars worked in the laboratories for 12 weeks during the summer. This internship provided housing, meals, and fees including 2 credit hours under special problem research, and allowed students to participate in Washington Carver summer program activities including *dinner and dialogue* and socials. At the completion of their 12-week internship, each of the scholars wrote the equivalent of a rough draft of a scientific research paper and made an oral presentation that would be quite comparable to a master's student presentation at a national professional meeting.

#### **Impact**

Based on the success of this program, the IFT is using this as a model and has extended to continue this program through 2008. This program has bolstered the self-confidence of all nineteen students who went through this program. The experience these students received motivated most of them to pursue graduate study. Many of these students have been co-authors on peer-reviewed scientific articles, which will strengthen their applications for graduate school. This program provides a vehicle to enhance diversity at the University of Arkansas.

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## **General Agriculture master's program offered to citizens statewide**

#### **Issue**

The Dale Bumpers College of Agricultural, Food, and Life Sciences offers a General Agriculture non-thesis master's degree program that is focused primarily toward "non-traditional" citizens of the state who wish to pursue an advanced degree but are not able to conduct this work in residence on

the Fayetteville campus. A clientele group that heavily relies on the accessibility of quality graduate-level courses is county extension agents and high school teachers who wish to obtain an advanced degree. Our college has utilized closed interactive video systems (CIV) and Web-based approaches to some degree to offer courses, but the array of offerings is limited. At least two practical obstacles appear to have precluded rapid expansion of our course offerings for off-campus students. While CIV is a very effective mechanism for teaching students at remote sites, the availability of technology and studios in Arkansas is very limited. Web-based courses overcome this problem by making course lectures available through the Internet, which is more widely available to potential students. However, courses that deal with the biology of organisms or plants routinely rely on hands-on student learning via on-campus laboratories, which has historically precluded these courses being available to students who are not in residence on campus.

#### **Action**

In 2002, Dr. R.T. Robbins and I offered Plant Nematology (PLPA 6303) via CIV for students on campus, allowing me to co-teach the course. Since all students at that time were resident on-campus, Dr. Robbins provided the hands-on laboratory that was required for course credit. In 2006, due to requests by 10 off-campus students to learn about plant nematology, Dr. Robbins and I developed and conducted two all-day laboratories at the Lonoke Agricultural Center (center of the state) that exactly mimicked the laboratory instruction that was offered to those on-campus students that were enrolled. Based on student performance and the suggestions of all students, I worked with Dr. C.S. Rothrock to offer his course, Principles of Plant Pathology (PLPA 3404) to both on- and off-campus students during the fall 2007 semester. The laboratory component of this course was included in four 8-hour sessions for off-campus students at the Lonoke Agricultural Center. As a service to Dr. Rothrock, Dr. Rick Cartwright and I provided support and assistance for each of the labs. Also during 2007, Dr. Cartwright and I developed a new course, Advanced Plant Disease Management (PLPA 4304) that will also be offered to both on- and off-campus students as a Web-based course with appropriate laboratory instruction at Lonoke. This course has been submitted to the DBCAFLS Course Curriculum Committee for approval, and will be offered in spring 2008 if approved.

#### **Impact**

The motto of the Division of Agriculture is "Arkansas is Our Campus." The development and modification of quality graduate-course offerings that are accessible to Arkansans outside the Fayetteville campus community will extend our teaching as well as our research and service efforts to the entire state. We have been able to demonstrate that both quality lecture instruction is possible outside the campus, and that quality laboratory experience is also possible for our non-traditional students. The availability of these and other courses, when they are adapted, opens new opportunities for Arkansans who want to continue their education

beyond the undergraduate level, but for whom an advanced degree through the University of Arkansas was out of reach.

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#### **Funding**

Division of Agriculture, University of Arkansas

## **Beef Quiz Bowl enhances learning, leading to improved knowledge in beef cattle production**

#### **Issue**

The University of Arkansas Division of Agriculture provides many successful programs for the youth in Arkansas. However, there was a need to provide students with a stronger background of information to better utilize and understand the beef cattle production aspects that can venture further than those of their beef 4-H and FFA projects.

#### **Action**

The Department of Animal Science initiated a program to give students in Arkansas an incentive to learn more about management, food safety, quality assurance, and the end product. Educational material was provided for county extension agents and vocational agriculture instructors to further the learning process for Arkansas youth in these areas.

Students compete in an annual quiz bowl where they are tested on many levels of question difficulty. The questions are formulated by our faculty and graduate students and are comprised of all aspects of beef production. Four students make up a team, and these teams compete in a double elimination tournament.

#### **Impact**

Through this program, students have the opportunity to sharpen their knowledge about beef cattle production. Additionally, these students will improve communication, goal setting, critical thinking, and team-building skills and ultimately enhance their interest in beef cattle.

Twenty teams participated in 2007. This program has a great impact on educating students on their role in beef production and strengthens their knowledge on the importance of beef cattle management and how it can greatly affect food safety and consumer acceptance. These efforts will be con-

tinued through the University of Arkansas Animal Science Cooperative Extension Service, Arkansas Beef Council, and agriculture teachers across the state.

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#### **Funding**

Arkansas Beef Council; Division of Agriculture, University of Arkansas

## **Improvements in the MS AFLS degree program**

#### **Issue**

The Master of Science in Agricultural, Food and Life Sciences (MS AFLS) is a graduate degree program that has served Arkansas agriculture for decades. It was previously known as the Master of Science in General Agriculture, and many agricultural science teachers and extension agents in Arkansas are graduates of the program. Recently, the name of the program was changed to more appropriately recognize the breadth of disciplines involved and the flexibility of the degree program to address specific student interests. The program was also expanded with the initiation of an option for studying food safety in 2006. During the past two years, administrative and programmatic changes have enhanced the scientific depth of the graduate training while maintaining flexible program options for specific student interests. The program continues to emphasize graduate degree options for off-campus students in a broad range of agricultural, food, and life sciences.

#### **Action**

Concurrent with the change in program name and expansion into a food safety option, the administrative structure of the program was reorganized with the appointment of a new program coordinator and the assignment of administrative support to better manage the program. A steering committee composed of graduate faculty from each academic discipline and representatives of off-campus faculty with the Arkansas Agricultural Experiment Station and the Arkansas Cooperative Extension Service was retained and restructured for academic oversight of the program. The program description was revised and a program Web site was created to enhance communication among the diverse faculty and students involved. A formal linkage to the School of Continuing Education and Academic Outreach was similarly strengthened with increased involvement in student support services and delivery of off-campus courses. Administrative activities also included the development of an internal database for tracking student progress and ongoing strategic discussion of the focus of the program and linkages to other degree program. The Associate Dean, in cooperation with the School of Continuing Education, has organized educational programs to encourage additional

development of off-campus courses. The Steering Committee expanded educational options by allowing students to substitute a formal thesis for a special project. Statements about student and faculty responsibilities, overall degree expectations, and steps to complete the degree were developed and added to the program Web site. A proposal for a seminar course was approved, and beginning in 2008, an AFLS graduate seminar will be offered each fall semester. The content of the seminar will address overall objectives for competency in understanding science and appreciating the breadth of agricultural, food, and life sciences. The program is dynamic and under constant review and revision. We recognize the importance of this graduate degree for off-campus agriculturalists, and the expanding interest of the food industry is a strong encouragement for continued growth and refinement. The unique needs and capabilities of off-campus students challenge traditional academic structure, but the rewards from a stronger workforce and agricultural system are large.

#### **Impact**

Expanding the breadth of the program to include Food Safety doubled the number of active students. Strengthening scientific requirements and adding flexibility has encouraged faculty support for the effort, especially among off-campus faculty. Diversity of courses remains a challenge, but opportunities for more courses should expand as enrollment and graduate success become recognized. The program remains as a critical option for continued graduate study of many agricultural professionals. Enhancing image and quality of the graduate program are essential aspects of continued program growth and success.

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## **Basis trading simulation software to develop grain merchandising and risk management skills**

#### **Issue**

Risk management and basis trading are key activities for agribusiness firms involved in the procurement, merchandising, processing, and marketing of grain and other commodities. The importance of these activities has been highlighted by globalization, which has led to increased price volatility

and competition for U.S. grain. The grain industry is international in scope with major players such as Cargill and Archer Daniels Midland (ADM) buying and selling grain within hundreds of countries worldwide. Evidence of globalization of the grain industry is visible in terms of elevator bids at major U.S. ports, which reflect international supply and demand conditions. Price shocks to world grain markets are quickly transmitted via bids at these ports to the hinterland (McKenzie, A.M. "The Effects of Barge Shocks on Soybean Basis Levels in Arkansas: A study of market integration." *Agribusiness: An International Journal* 21(1) 2005. 37-52.). However, a major advantage of U.S. grain industry over foreign competition is ease of access to developed commodity risk-management markets (e.g. Chicago Board of Trade futures and options markets). In order to remain competitive, merchandising firms increasingly rely on basis trading skills, which developed alongside the futures markets to provide a cost-effective yet profitable service to grain buyers throughout the world. Thus globalization can be seen as a driving force behind greater price risk and increased competition within the U.S. grain industry. With this in mind, the grain industry's need for students with price risk-management and basis-trading skills has never been keener. However, there is a lack of undergraduate agribusiness course materials on basis-trading and risk-management education at the merchandising level of the grain industry, where most agricultural risk-management activities occur and where many employment opportunities for students are found. Existing university risk-management course materials focus exclusively at the farm level.

#### **Action**

A basis-trading software game, developed by the University of Arkansas Division of Agriculture to teach merchandising and price risk-management skills, has been made available at the Department of Agricultural Economics Web site (<http://www.uark.edu/ua/btrader/>). "Basis Trader" is an engaging risk-management game using computer technology to provide an experiential learning experience that develops students' analytical decision making skills at an applied level. It explores concepts such as basis trading and hedging by simulating basis movement, historical basis patterns, inventory management, and the procurement and sale of grain based upon actual data collected from grain elevators in Arkansas, Tennessee, Illinois, Kansas, South Dakota, and Wisconsin. Players take on the role of grain merchandisers seeking to market corn, soybeans, and wheat, and can choose from a number of different market locations. Players are faced with marketing and risk-management decisions, including the following: how much grain to hedge, what contract months to hedge against, how long to store grain, and when to sell it. Problem-solving skills are emphasized in terms of making marketing decisions with respect to current and historical futures spreads, current and historical basis levels, elevator storage capacity, and the cost of storing grain over time.

#### **Impact**

Important outcomes and impacts of the game and

materials will include the fostering of a better-educated student body with the skill-set and motivation needed to pursue successful careers within the grain industry. This potential workforce will help the U.S. grain industry remain competitive and better serve the needs of the general economy. Tangible outcome measures will be represented by: more institutions incorporating the project materials in marketing and risk-management courses; improved test scores in risk-management course tests; increased student enrollment in agribusiness marketing and risk-management classes; and an increased number of students seeking internship and full-time career opportunities in the grain industry. It is hoped that agribusiness programs from land-grant universities and colleges throughout the country will adopt the project materials within their curricula. The game and materials will also provide farmers across the nation with the opportunity to more fully understand the intricacies of the grain marketing system beyond the farm gate.

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## European international graduate student exchange and curriculum development in renewable resources and clean technology

#### Issue

An international education or research experience is becoming an invaluable asset for introducing cultural and foreign language skills to students preparing for careers in agriculture-related disciplines. This is especially true for the developing multidisciplinary fields of *clean technology* and *renewable resource utilization*. Clean technologies that reduce energy demands and toxic emissions with enhanced renewable resource utilization are becoming increasingly important worldwide. In addition, producing materials and chemicals from agricultural co-products reduces dependence on fossil fuels. Europe has led the world in many of these technologies including *biorefinery* technology and *biofuel production*. Transatlantic student opportunities to obtain international experience in these fields by studying in Europe and hosting students at the University of Arkansas would be of great personal and professional benefit to students and the UA.

#### Action

The UA is the lead American institution in a U.S. Department of Education-funded project, *Renewable Resources and Clean Technology*. The other U.S. partners are Iowa State University and University of Washington. These American universities are collaborating with University of Gent, Belgium; Karl Franzens University, Graz, Austria; and National Polytechnic Institute of Toulouse, France, and have obtained parallel funding from the European Union. The

major project objective is to facilitate transatlantic student exchanges to obtain research and education experience in technologies of value to the home institution and state. This program provides our students with experience in European centers of excellence in these fields and valuable technical and international experience and faculty with unique networking opportunities to broaden and internationalize their professional horizons. Furthermore, the UA and the U.S. partners are providing EU students with a unique study experience in America.

University of Arkansas students have studied starch modification for development of new materials in Graz; commercial biodiesel production in Gent; biodiesel economics, also in Gent; new natural products development in Toulouse; and have investigated using a modified starch as an alternative, slow drug-release system in Gent. In 2007, UA students studied biomass genetics and recycling poultry litter as a value-added fertilizer. Students also take classes and study the host country's language. We have hosted 5 EU students from Gent and Graz at the UA who have conducted research on bio-hydrogen production, low-energy extraction techniques, natural antioxidants, starch modification, or chemical analysis with minimal solvents, while also taking classes. We will host 3 EU students in Spring 2008 who will conduct research on fermentation and natural antioxidant projects.

#### Impact

College student and faculty interest in this international experience have developed during the project. In particular, faculty have been very supportive of their students' involvement. Graduate students are appreciating the importance of overseas experience in this field that will make them more competitive in the job market. Faculty have been able to develop useful research collaborations for the future. Furthermore, EU students have learned how attractive our graduate programs are and we anticipate at least one graduate-school application from an EU student who completed this program.

The program has demonstrated how to provide an international dimension to our study programs at modest expense. Furthermore, the transatlantic faculty-faculty interaction in designing student programs has already established working relationships and proved to be a useful networking device. We have hosted EU professor visits during each year of the project. Our European colleagues are eager to work with our faculty in addressing renewable resource and clean technology affecting Arkansas. These relationships could become increasingly important as we address issues related to fossil fuel shortages that necessitate new technologies and novel utilization of our agricultural resources. This in turn will expand European graduate student research and education opportunities.

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**Funding**

U.S. Department of Education, Fund for Improvement of Post Secondary Education; Division of Agriculture, University of Arkansas



### *2007 Publications of the Arkansas Agricultural Experiment Station*

- DISCOVERY: The Student Journal of the Dale Bumpers College of Agricultural, Food and Life Sciences, Vol. 8*
  - Considerations for Starting a Winery*
- The Muscadine Experience: Adding Value to Enhance Profits (2nd edition)*
  - Arkansas Turfgrass Report 2007*
  - Arkansas Small-Grain Cultivar Performance Tests 2006-2007*
  - Arkansas Corn and Grain Sorghum Performance Tests 2007*
    - Arkansas Soybean Performance Tests 2007*
    - Arkansas Cotton Variety Test 2007*
  - Animal Science Department Report 2007*
- Wayne E. Sabbe Arkansas Soil Fertility Studies 2006*
  - B.R. Wells Rice Research Studies 2006*
- Summaries of Arkansas Cotton Research 2006*

### *Other selected publications of the Arkansas Agricultural Experiment Station*

- A Century of Research: Centennial History of the Arkansas Agricultural Experiment Station 1888 - 1988*
- History of the Bumpers College: Evolution of Education in the Agricultural, Food and Life Sciences in Arkansas*
  - Arkansas Global Rice Model: International Baseline Projections for 2000-2010*
- Evaluation of Small Grain Forage Crops and Cultivars of Soft Red Winter Wheat for Stocker Cattle*
  - Soils of Jackson County, Arkansas*
  - Soils of Clay County, Arkansas*
  - Soils of Desha County, Arkansas*
  - Soils of Mississippi County, Arkansas*
  - Soils of Arkansas County, Arkansas*
- Field Evaluation of Herbicides on Rice 2005*





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