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ALABAMA AGRICULTURAL EXPERIMENT STATION  
AUBURN UNIVERSITY

*SPCC*

# HIGHLIGHTS

OF AGRICULTURAL RESEARCH



# In this issue

## from the Director

IN FISCAL YEAR 1995-96, the AAES will undergo a budget reduction that will require us to terminate some of our research programs.

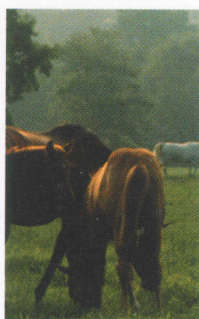
The initial process to prioritize projects was initiated last year. University-wide similar reductions and subsequent prioritization has been ongoing the past year. These are austere times, but times in which we can restructure our programs to most efficiently meet the needs of the future.

Budgetary cuts will be especially difficult to implement at some of our outlying research units. However, I've found some of our most innovative people are working at the substations, and if anyone can persevere and thrive during hard times, they will do it.

On campus, we have to make some hard decisions as to which programs to support and on which to cut back and/or eliminate. These are not simple decisions, because all our research programs are important.

For too long we have eaten our proverbial seed corn. We have taken research results and adapted the technology to production agriculture, but we haven't consistently re-invested in our research programs nationwide. As a result, the technology producers need to push on to the next frontier of food and fiber production may not be there.

These aren't the cards we would like to hold, but they are the ones we've been dealt. And, we intend to play them to the best of our abilities.



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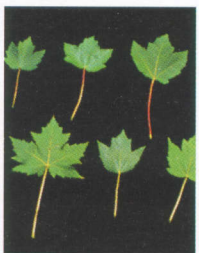
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ON THE COVER: Many people rely on red maple foliage to provide color in the fall landscape, but not all cultivars are suited to Alabama's growing conditions. See article on page 8.

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A QUARTERLY REPORT OF RESEARCH PUBLISHED BY THE ALABAMA AGRICULTURAL EXPERIMENT STATION, AUBURN UNIVERSITY.

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# NEW OPPORTUNITIES FOR SPORT FISH POND FERTILIZATION

Yancey R. Brown, Draughton, and E. Boyd

OCT 23 1995

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**G**reater fish production and decreased weed growth are two good reasons for fertilizing sport fish ponds in the South. Fertilizer nutrients cause plankton blooms by increasing the abundance of microscopic plants and animals. Plankton blooms eliminate underwater weeds by shading and serve as food to support larger fish populations.

An AAES research project compared the effectiveness of commonly used solid and liquid fertilizers with two new products. One new product is a controlled-release fertilizer (CRF) introduced on the market in 1995. The other, introduced in 1993, is a powdered, water-soluble fertilizer (WSF) that dissolves almost instantly. These products have attracted the attention of pond owners and state agencies, and several private consultants and hatcheries are already using them.

Conventional, solid fertilizers, applied as prills or grains, have been used for at least 50 years. These fertilizers usually are applied to ponds at rates equivalent to 0-10 pounds of nitrogen (N) per acre and 8-10 pounds of phosphorous (P) per acre; applications are made at three- to four-week intervals between early spring and late fall. AAES research in the 1980s demonstrated that nutrient



*New fish pond fertilizers are not only as effective as traditional fertilizers, they are safer for the environment.*

inputs for pond fertilization could be reduced 50-75% by using liquid fertilizer. A popular liquid fertilizer now used in Alabama has 10% N and 34% P (10-34-0). It must be applied at three- to four-week intervals to maintain adequate plankton blooms. Because liquid fertilizers are denser

than water, they must be premixed with water and then splashed or sprayed over the pond surface from a boat.

A single dose of CRF (13-13-13) made in the early spring grad-

**Fertilization, continued on page 4**

**Table 1. Production of Sunfish Using Various Fertilizers in Experimental Ponds at Auburn University**

Treatment	Applications		Phosphorous rate <sup>1</sup>		Fish production <i>lb./a.</i>
	No./year	Lb./year	Per application	Per year	
None	<i>lb./a.</i>	<i>lb./a.</i>			
None	0	0	0	0	100
WSF	10	2	1	10	305
CRF	1	69	9	9	317
Liquid	10	40	8	80	321
Conventional	10	12	4	40	335

<sup>1</sup>Phosphorous is usually the limiting factor in most freshwater systems. Nitrogen is sometimes limited, but fixation from bluegreen algae and decomposition from bacteria often provide adequate nitrogen for good plankton growth.

ually released nutrients into the water and maintained a good plankton bloom throughout the growing season. Fish production was similar to that achieved in ponds treated at four-week intervals with liquid or conventional fertilizer, even though annual phosphorous input was much less (Table 1). However, a controlled-release fertilizer containing about 10-15% N and 34-48% P would provide

rates — 2-8 pounds per acre per application. Plankton blooms were adequate throughout the growing season, and fish production did not differ among treatments. Fish production in ponds treated with two pounds of WSF was as good as that achieved with other fertilizers (Table 1).

Because of their history of good fertilization and management, research ponds often respond better to nutrient inputs and require slightly less fertilizer than the typical sport fish pond. The current application rate for liquid fertilizer is based upon a decade of work in both sport fish and research ponds. However, there is little experience with the use of water-soluble and controlled-release fertilizers, and it is possible that some ponds may need higher application rates than indicated in Table 1.

In addition to being effective, CRF and WSF are cost competitive (Table 2) and environmentally superior to other pond fertilizers. CRFs minimize nutrient loss to the bottom soils by releasing nutrients gradually and supplying plankton with smaller quantities on a more regular basis. This also prevents the

**Table 2. Cost Comparison of Different Fertilizers**

Treatment	Cost <sup>1</sup>
No Fertilizer	0
WSF	\$28.00
CRF	\$32.50
Conventional	\$56.00
Liquid	\$30.00

<sup>1</sup> Cost to treat one acre for one year.

feast or famine syndrome experienced by plankton as a result of monthly fertilizer applications. CRFs also eliminate the necessity for monthly applications. Although they still require applications at three- to four-week intervals, WSFs reduce nutrient loss because they dissolve immediately and permit rapid nutrient uptake.

While all four fertilizers provide similar fish production when properly applied, it is difficult to say which is best. There are advantages and disadvantages to all forms of fertilizer, and each pond owner must find the form that is most suited to his or her management goals.

Liquid fertilizers are inexpensive and completely soluble, but they must be diluted before use. Granular fertilizers require no dilution, but they are expensive and require the use of a fertilization platform. CRFs, in theory, enable pond owners to make only one application per year, but in reality, additional applications might be needed in the cooler months when the fertilizer release rate is lower. Finally, WSFs provide the benefits of liquid fertilizers, but they must be spread in deeper water to prevent adsorption by pond sediments, and they are sometimes difficult to find in stores.

Rushton is a Graduate Research Assistant and Boyd is a Professor in Fisheries and Allied Aquacultures.



Every pond reacts differently to fertilizer and nutrient input as shown in North Auburn Fisheries Unit above.

better results than the 13-13-13 CRF used. Current AAES research is being conducted on CRFs that have an analysis more suited for pond fertilization.

The WSF product (10-52-4), which is composed of powdered monoammonium phosphate, was evaluated at different treatment



## Channel Catfish Recover Quickly From Restricted Feeding

**C**atfish restricted from feed for three weeks, then fed all they wanted, weighed the same as fish fed continuously at the end of an 18-week growing season, according to recent AAES research. In addition, fish restricted from feed for six and nine weeks completed the growing season at 91% and 87% of the final weight of fish fed continuously.

Compensatory weight gain following a period of restricted food intake is well recognized in livestock, but no research information is available on this phenomenon in fish. Sometimes, because of disease or water quality problems, or because farmers are short on cash, labor, or pond space, catfish are not fed for a period during the growing season. A study was conducted at the AAES to determine if channel catfish restricted from feed for three, six, and nine weeks during an 18-week growing season could catch up to fish fed continuously.

Fingerling channel catfish averaging approximately 1.5 ounces were

stocked in earthen ponds (5,500 per acre) in early spring and maintained on the same feeding regimen until June 1, when daytime water temperature reached optimum feeding temperature of 82-84°F. Subsequently, three groups of fish (three ponds per group) were held on restricted feeding for various periods. All fish were fed as much as they wanted daily once they were off restricted feeding. A control group of fish was fed as much as they wanted daily throughout the 18-month growing season.

Fish weight, body fat content, muscle fiber diameter, and feed consumption were measured at three-week intervals for the 18-week grow-out period (see table). Fish held on restricted feeding for three weeks weighed the same as those fed continuously at the end of the trial; in fact, they required only three weeks of full feeding to catch up with the control. Fish on restricted feeding for six weeks weighed 91% as much as

the control at the end of the trial. Fish on restricted feeding for nine weeks weighed 87% as much as the control at the end of the experiment. Feed conversion was almost identical for the four groups of fish, indicating that feed assimilation was consistent, whether fish were fed continuously or not.

Once feeding resumed, body fat and muscle diameter were immediately and significantly lower among fish in the feeding restricted groups. However, at the end of the 18-week cycle, body fat content was essentially the same for all four groups, though muscle fiber diameter was smaller for the fish on restricted feeding for six and nine weeks. Body fat content increased quickly after the fish went on full feed, but muscle fibers filled out more slowly. Dressing yield was slightly less for fish on restricted feeding for six and nine weeks.

These results indicate that at optimum growth temperature, two-year-old channel catfish will quickly recover from three weeks of feed restriction, if they are fed as much as they will eat when put on full feed. Results also show that muscle mass and body fat change with temporary feed restriction in growing catfish. These studies show that catfish can catch up in weight gain following relatively long periods of restricted feeding provided they are subsequently fed all they want to eat.

Lovell is a Professor and Kim is a former Graduate Research

**Effects of Limited Feeding of Channel Catfish Fingerlings During an 18-Week Grow-Out Period**

Variable	Weeks deprived of feed			
	0	3	6	9
Weight gain (grams) <sup>1</sup>	553	555	503	481
Weight gain (pct. of control)	100	100.3	91	87.0
Feed conversion (feed/gain)	1.32	1.35	1.35	1.32
Whole body fat (pct.)	11.8	12.0	12.2	12.9
Muscle diameter (m)	84.0	84.5	84.0	74.5
Dressing yield (pct.)	63.1	63.4	62.8	62.8

<sup>1</sup> One ounce equals 29 grams.

# HORSES HAVE A MAJOR IMPACT ON

**H**orses are an integral part of life in Alabama. Horse production, training, and events make major contributions to the rural economy. Nearly every county has horse organizations, farms, and show or performance facilities.

Many counties have a regular schedule of equine activities. Breeding and sales, racing, recreation, showing, and other endeavors are significant sources of income, employment, and leisure.

An AAES study found the annual turnover of horse-related expenditures to exceed \$563 million, about .1% of the gross state product. This overall impact includes expenditures by horse owners, related businesses, and tourists traveling to various equine activities. Several regional and national shows, the Birmingham racetrack, and a multitude of rodeos, polo matches, field trials, trail rides, open shows, and other equestrian events fuel the majority of these expenditures.

Horses have impacts on the rural economy through: the service businesses they support—farriers, trainers, and veterinarians; breeding fees and sales; spectator and participant travel and entertainment expenses away from home; and the largest category, care and maintenance. Owners buy feed, materials, health care products, insurance, and services for horses every day. Buildings, trailers, fences, and pasture maintenance

are expenditures linked to horses. Horse shows and competitions create demand for clothing, tack, and other items.

The average annual cost of keeping an Alabama racing horse in training was estimated to be \$15,390 in 1990. The estimated average annual cost of keeping a show horse was \$11,005. Although professional showing is a much more widespread activity than racing, the high levels of expenditures for each set of animals reflect the more intensive level of care and maintenance required to keep them in proper condition. The figure shows spending for each use distributed over four cost categories.

Horses used for purposes other than racing or showing are classified as recreational-use horses. Their owners spend about \$3,140 annually per horse for care and maintenance. Expenditure levels for these animals reflect lower care and maintenance needs associated with horses not actively showing, racing, or competing in other events. Although the study did not estimate separate budgets for breeding stock, expenses for these animals probably approximate the keeping of a recreational horse.

Horse shows are a pervasive part of rural life in Alabama. Shows are competitions in which prizes are awarded based on body conformation, groomed appearance, physical capabilities, and behavioral performance of the horse and rider. Shows provide an opportunity for horse owners, trainers, breeders, and riders to display their animals. Shows stim-



ulate interest in breeding stock and training procedures because winning horses and trainers command higher sale prices and fees. On average, owners of active show horses spent

# ALABAMA ECONOMY AND RURAL LIFE

Joseph J. Molnar, Cynthia A. McCall, Regina Broadway, and Robert M. Pendergrass



stems from food and lodging for personnel accompanying the horses, as well as services and supplies purchased for the horses. For example, each out-of-state horse stabled at the track or horse show may generate about \$90 per day. Though a small facility with a short program may attract relatively few horses, the total impact can be large.

Horses have significant links to agriculture. About 16% of the national agricultural and agribusiness gross economic product can be attributed to the horse industry. Horse production, care, and maintenance create demand for oats, corn, clover, alfalfa, hay, and other feed crops produced by Alabama farmers. Horse keeping, breeding, and raising help retain the agricultural infrastructure in areas where farms are few

in number. Horse pastures, fences, and barns often add to the aesthetic appeal of the Alabama countryside.

The authors estimate that 5% of Alabama households have some personal or familial connection to horse ownership, breeding, or competition. More people are involved with horses than is commonly recognized by the institutions that serve agriculture and the recreating public.

This lack of recognition is due to the traditional nature of the Alabama horse industry: a loosely connected aggregate of breed- and activity-related associations, each with unique organizational arrangements. This fragmentation and lack of a unified voice obscures the considerable importance of this industry

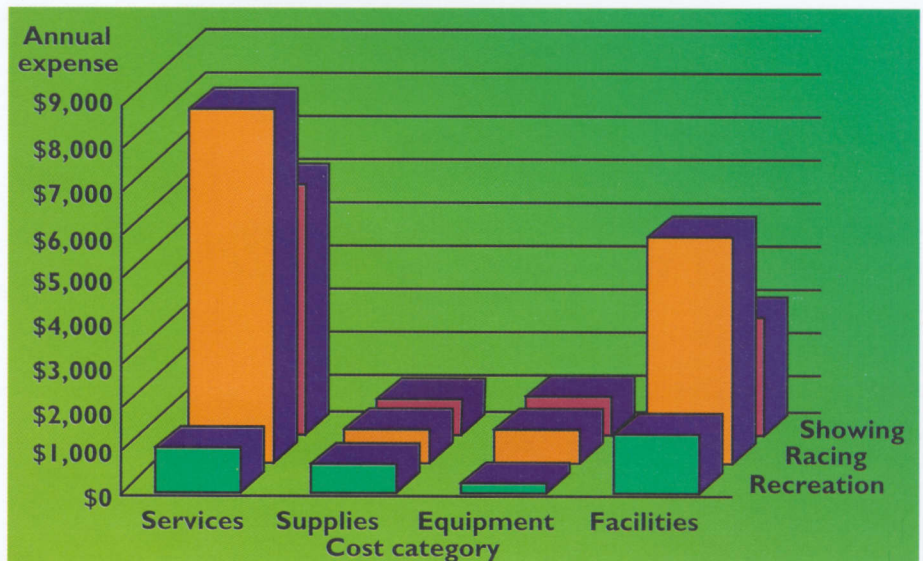
**Horses, continued on page 9**

\$1,495 annually on travel and related expenses to participate in horse shows. The estimate includes expenditures for fuel, food, and lodging for the people traveling with the horse, as well as stall fees, and registration fees for the horse.

The impact of rodeos is concentrated in the communities that host the rodeos. Most of a rodeo's effects on the local economy are derived from the spectators because there are typically many more spectators than contestants in a rodeo's events. Rodeo spectators generate economic activity through admission fees, concessions, and souvenirs.

Out-of-state horses stabled in a locale represent a significant economic impact to the area. This impact

Care and maintenance expenditures for three horse uses in Alabama, 1990.



# RED MAPLE CULTIVAR PERFORMANCE IN THE SOUTHEAST

Jeff L. Sibley, D. Joseph Eakes, Charles H. Gilliam, Gary J. Kever, and William A. Dozier, Jr., and John T. Owen

When landscapers and homeowners plant red maple seedlings, they expect rapid tree growth, attractive canopy form, and excellent red fall color. Unfortunately, red maples show considerable variations when grown from seed. On the other hand, red maple cultivars, which are cloned from tissue collected from a superior mother tree, are uniform in shape, foliage, and color.

However, cultivars are often selected for Alabama based only on evaluations in the plants' native regions. Many of these cultivars prove to be unsuitable for the Southeast. Of the 52 named red maple cultivars, none have been released from selections originating in the southern portion of their native range, which extends throughout the Eastern U.S. and Canada.

To address this problem, an AAES study identified several superior red maples for urban and residential landscapes in the Southeast. Determination of suitable red maple cultivars for the region can increase the selection of shade and ornamental trees.

Cultivars included in the AAES trials represent a broad cross section of the classified red maples (*Acer rubrum* L.). Red maple cultivars known to perform well in the Southeast were compared with selec-



Figure 1. Typical fall color of Autumn Blaze; (inset) foliage of red maple cultivars (top row, left to right): Armstrong, Autumn Blaze, Autumn Flame, Bowhall, Fairview Flame, Gerling, Karpick, (bottom row, left to right) Morgan, Northwood, October Glory, Redskin, Red Sunset, Scarsen, Schlesingeri, and Tilford.



tions from the Freeman maple group. Freeman maples are generally grouped with red maple cultivars, but are recognized botanically as *Acer x freemanii*, a cross between red maple and silver maple (*Acer saccharinum* L.).

Cultivars were obtained in March 1988 from Microplant, Inc., in Fairview, Ore., and grown in containers for two years. Trees ranged from four to five feet tall when transplanted in March 1990, into a Cecil gravelly sandy loam soil at the Piedmont Substation. Trees were planted on a 30x35 foot spacing and were fertilized with one pound of nitrogen, phosphorus, and potassium (13-13-13) per inch of caliper at planting and in March of following years before bud break. Drip irrigation was supplied to each tree.

*Acer x freemanii* cultivars included Autumn Blaze, Morgan (Indian Summer), and Scarsen (Scarlet Sentinel). *Acer rubrum* cultivars included Autumn Flame, Fairview Flame, Franksred (Red Sunset), Karpick, Northwood, October Glory, Redskin, Schlesingeri, and Tilford. Since the traditional practice has been to plant trees from seed, a group of seedlings from seed collected at A. McGill & Son Nursery of Fairview, Ore., were planted for comparison.

Autumn Flame and three Freeman maple selections, Autumn Blaze, Scarsen, and Morgan, generally increased the most in height over the five years (Table 1). Northwood increased the least in height, about one-half that of most other cultivars. Average annual height increase for Autumn Flame was 117% greater than had been reported in previous

studies; Franksred, 50% greater; Scarsen, 47% greater; Schlesingeri, 36% greater; seedlings, 71% greater; and Tilford, 35% greater. These enhanced growth differences could be attributed to the use of irrigation or own-root trees versus budded trees.

Caliper increases did not follow height increase trends from 1991 through 1994 as a general rule. While the Freeman group selections had a tendency for height growth typical of silver maple, the caliper growth on an annual basis was different for each. Among the 13 selections, Autumn Blaze, an *A. x freemanii*, had the greatest annual increase in caliper. Most selections developed greater increases in caliper each successive year following establishment until 1994. Caliper increases were lower in 1994 than 1993 for all but Autumn Blaze (Figure 1).

Fall color duration varied yearly. The longest duration of fall color in 1992 occurred with October Glory and Fairview Flame, while in 1993 Fairview Flame, Schlesingeri, Franksred, and October Glory had the longest duration of fall color (Figure 2).

Cultivars showed greater variability in the timing of peak fall color in 1992 than in 1993. In both years Northwood and Morgan were the first cultivars to exhibit fall color and to have fall color peaks. However, Northwood had completely defoliated near the time Autumn Blaze was at its peak and before October Glory had begun to display notable fall color. Peak fall color was displayed 7-10 days later in 1993 for most cultivars. For the two seasons

for Alabama's rural economy.

To address this problem, horse industry and Auburn University representatives recently organized the Alabama Horse Council, which will promote development of the industry.

Spending by spectators, riders, owners, breeders, and trainers clearly helps to bolster Alabama's rural economy. Although the estimated 70,000 horses in Alabama are dwarfed by the 1.7 million cattle in the state, the impacts of horses are magnified due to the high value of each individual animal. Moreover, horses and horse activities often bring urban dollars to rural places, and most importantly, out-of-state dollars to Alabama.

Molnar is a Professor of Rural Sociology, McCall is an Associate Professor of Animal and Dairy Science, Broadway is a former Graduate Research Assistant, and Pendergrass is a Research Associate at the University of Tennessee Agricultural Policy Analysis Center.

that fall color evaluations were made, the cultivars Fairview Flame and October Glory had the best display of red coloration, based on typical color hue and duration, while Northwood, Morgan, and Redskin had poor fall color. Defoliation coincided with the end of fall color for most cultivars each year. While all trees of a particular cultivar developed the same fall color, only 20% of the seedlings in the AAES evaluation exhibited red fall color; other seedlings had yellow to brown fall color.

Superior red maple cultivars for the Southeast, based on fall color display and height and diameter growth, were Autumn Flame, Autumn

# COTTON DEFOLIANTS AND BOLL OPENERS SAFEGUARD QUALITY, IMPROVE HARVEST

Charles H. Burmester, Michael G.

**A**fter battling seedling diseases early, insects late, and weeds and grasses throughout the crop year, cotton farmers are then challenged to pick the right time to harvest their crop. If harvesting is done too early, not enough bolls are open; too late and open bolls lose quality, plus cold weather is a problem.

Defoliation often allows growers to pick mature cotton several weeks earlier than they could without defoliants, thus preventing loss of boll quality and reducing the risk of getting caught by bad weather late in the growing season. Though only a handful of cotton defoliants are currently registered for use, a three-year test at the Tennessee Valley

Substation in Belle Mina indicates certain treatments can result in good defoliation, high quality cotton, and increased profit for growers.

Defoliants registered for use on cotton are DEF/Folex, Dropp, and Harvade. These defoliants are often used in combination with Prep, which enhances boll opening, to allow for earlier and more complete harvest of the highest possible number of mature bolls. This combination of defoliant and boll opener also allows growers to harvest a field once, instead of "scrapping" (second harvest), which is rarely cost effective.

In the AAES study, seven core treatments were used as part of a nationwide test (see table), along with additional treatments sometimes used in the Southeast. Treatments were applied in a spray volume of 10 gallons of solution per acre when an average of 50-60% of cotton bolls were open. Visual defoliation ratings were obtained seven and 14 days after treatment. Seed cotton was harvested from plots receiving these treatments and ginned to provide lint which was

graded to determine the quality.

Defoliation treatments increased leaf drop 22-34% above untreated control plots. Mixtures of Prep with Folex, Prep with Dropp, and Prep with Harvade produced 5-11% more consistent defoliation over a wide range of environmental conditions than the products produced without the boll opener during the three-year study.

Cotton fiber thickness (micronaire), strength, and degree of whiteness were within commercially accepted ranges throughout the test period. Total yield was not significantly different when using Prep versus not using the boll opener. However, using Prep in combination with the defoliants produced from 6-

**Effect of Defoliants and Ethephon on Cotton, Belle Mina, Alabama, 1992-1994<sup>1</sup>**

Treatment	Defoliation	Micronaire	Strength	HVI	
				Rd	+B
	<i>pct.</i>	<i>units</i>	<i>g/text</i>	<i>units</i>	
1. Untreated	57	4.5	25	76	8.7
2. Folex, 16 oz.	79	4.4	25	76	8.4
3. Dropp, 0.2 lb.	80	4.4	25	76	8.4
4. Harvade, 8 oz.	82	4.5	25	76	8.4
5. Harvade, 6.5 oz. Prep, 1.33 pt.	87	4.3	25	75	8.7
6. Folex, 12 oz. Prep, 1.33 pt.	89	4.2	26	76	8.7
7. Dropp, 0.1 lb. Prep, 1.33 pt.	91	4.2	25	75	8.7
8. Dropp, 0.1 lb. Folex, 1 pt. Prep, 1.33 pt.	86	4.1	25	76	8.6
9. Dropp, .125 lb. Harvade, 6.5 oz.	86	4.4	25	76	8.4
10. Quickpick, 8 oz. Dropp, .125 lb.	80	4.4	25	76	8.5

<sup>1</sup> Micronaire acceptable range are 3.9 to 4.9; strength acceptable range, 23 and above; HVI RD and +B units acceptable according to classers grade. Defoliation was evaluated on a scale from 0-100, where 0 = no defoliation and 100 = complete defoliation.



15% higher yields on the first picking each year. This indicates that defoliant do not adversely affect the quality of fiber harvested, while allowing growers to get their cotton out of the field earlier.

Previous studies have shown that the lint in an open boll loses approximately 1% of its weight for each day it is not harvested after opening. A two-week delay in harvesting cotton can result in significant economic loss due to the weathering of lint in open bolls. The proper use of defoliant and Prep can result in farmers harvesting high-quality cotton in a shorter period of time, which is good for the industry and consumers.

Burmester is an Extension Research Agronomist, Patterson is an Associate Professor, and Monks is an Assistant Professor in Agronomy and Soils.

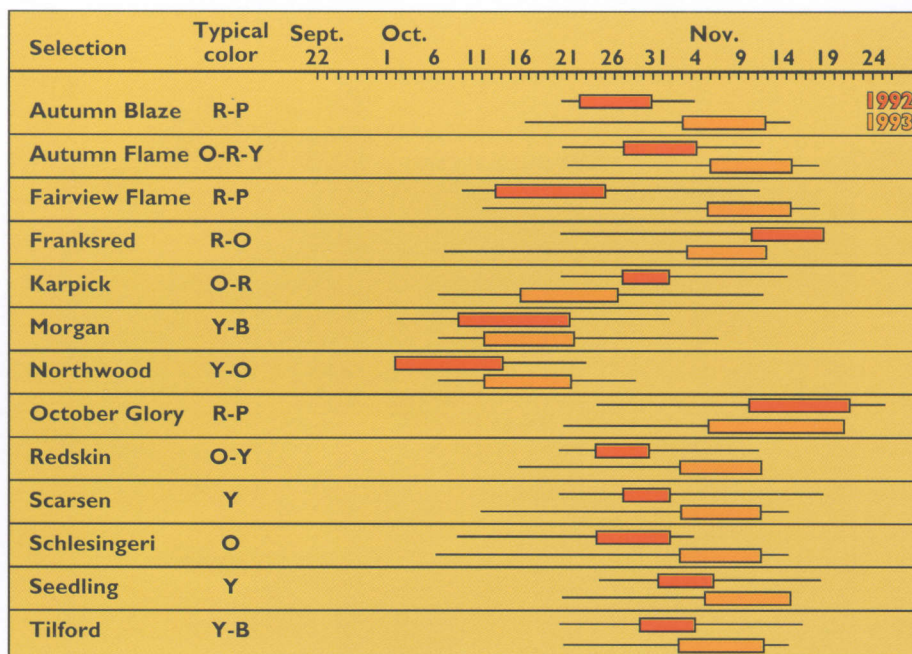


Figure 2. Hue and duration of fall color for red maple selections in 1992 and 1993. Color notation as follows: B = brown, O = orange, P = purple, R = red, Y = yellow (primary color listed first); — = Presence of color; ■ = Peak color period. Foliar fall color patterns were evaluated two or three times weekly from September through December of 1992 and 1993. Color peak was the maximum ranking the cultivar attained each season. Peak color periods were determined to be one observation prior to the peak date and one observation after the established peak.

Blaze, Fairview Flame, and October Glory. By this same criteria, Karpick and Northwood were poor selections. The Freeman red maple selections, along with *A. rubrum* Autumn Flame, had the best growth performance in this study with no apparent adaptability limitations to the climate of the Southeast.

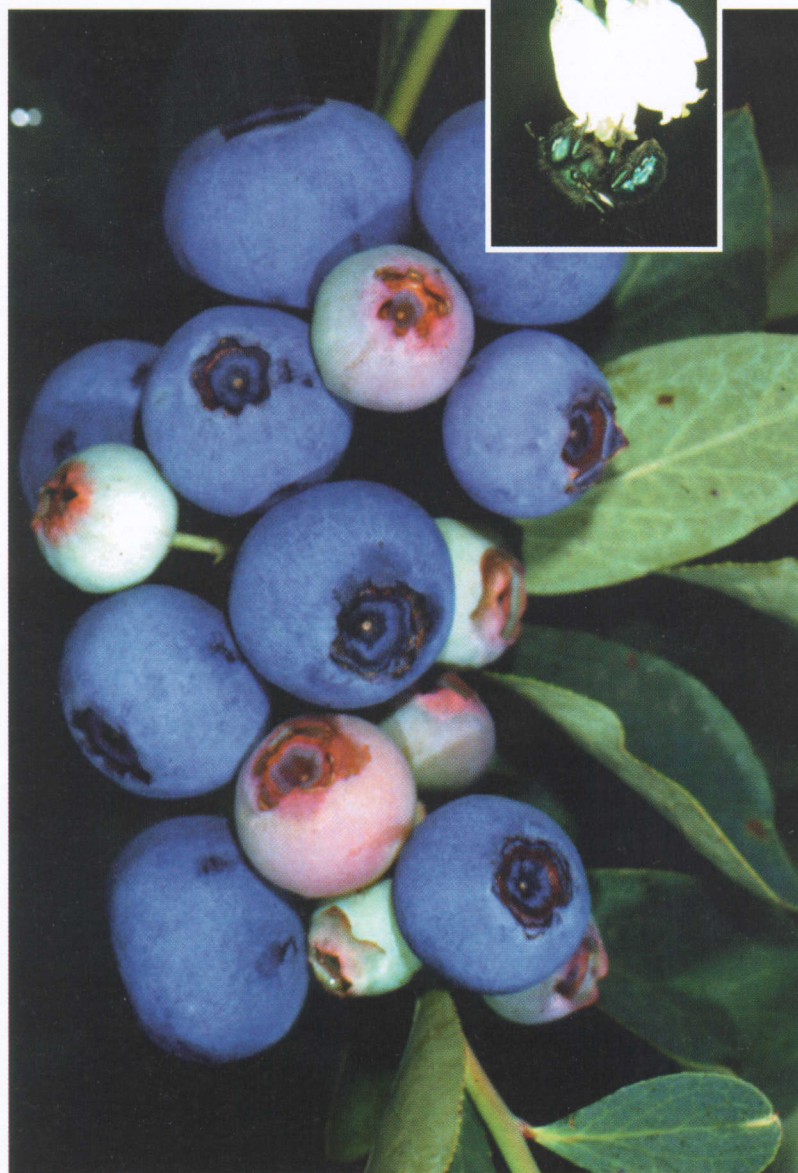
Sibley is a Research Assistant, Eakes is an Assistant Professor, Gilliam is a Professor, Keever is a Professor, and Dozier is Department Chair and Professor of Horticulture. Owen is Superintendent of the Piedmont Substation

Table 1. Height and Trunk Caliper of Red Maple Selections

Cultivar/seedling	Avg. annual <sup>1</sup> height increase		Final height		Avg. annual <sup>1</sup> caliper increase		Final caliper	
	in.	ft.	in.	ft.	in.	ft.		
Autumn Flame	35.0	18.7	0.94	5.2				
Autumn Blaze	39.0	18.9	1.06	5.4				
Scarsen	35.0	16.7	0.71	3.7				
Morgan	35.0	17.0	0.79	4.1				
Northwood	15.7	12.7	0.47	2.9				
Franksred	29.1	15.7	0.75	3.9				
Schlesingeri	30.7	14.6	0.79	4.0				
Seedling	34.6	17.8	0.94	4.8				
October Glory	31.5	16.9	0.87	4.7				
Fairview Flame	28.7	15.4	0.91	4.8				
Karpick	24.0	12.9	0.47	2.7				
Redskin	24.8	13.4	0.75	4.0				
Tilford	29.9	15.0	0.63	3.3				

<sup>1</sup> Growth increases were determined by the difference in current and the previous season's measurements from 1990-1994.

# BLUE BEES FOR BLUEBERRIES?



## NATIVE BEE MAY PROVIDE HELP FOR BLUEBERRIES

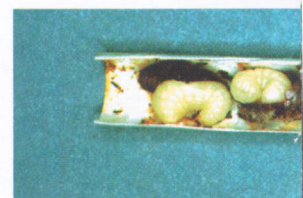


Figure 1 (inset on left): The native Southeastern blueberry bee. Figure 2 (above): A cross-section of a blueberry fruit showing a linear arrangement of larvae inside. (Photos: Lacy K. Jackson)

Cooperative research between the AAES and the USDA has shown that the Southeastern blueberry bee (*Habropoda laboriosa*), a native ground-nesting bee, effectively pollinates rabbiteye blueberry. However, Southeastern blueberry bees may be uncommon on larger acreages or in habitats lacking suitable nest sites. Honey bee hives have therefore been brought in each year to pollinate this valuable fruit crop. Unfortunately, their ineffectiveness at pollinating rabbiteye blueberry and their susceptibility to diseases and newly-introduced parasitic mites could limit their future use.

As a possible solution, commercial bumble bee colonies are now being considered for rabbiteye blueberry pollination, but their sophisticated management requirements and small colony size make them prohibitively expensive. The possibility of native bee shortages and a lack of a reliable and affordable commercial pollinator for rabbiteye blueberry underscore a need to find new and better pollinators for this crop.

In addition to the honey bee

**C**ommercial blueberry production is expanding in Alabama, with 5,000 acres of land currently planted. The most commonly grown blueberry species in the Southeast is rabbiteye, *Vaccinium ashei*. This species requires bees for pollination and fruit set, but not any bee will do. Rabbiteye blueberry has specialized flowers and its pollen must be transferred between bushes of compatible varieties to set fruit.

# NEW POLLINATION BLUEBERRY PRODUCERS

Blair Sampson, Jim Cane and John Neff



Figure 1: *Osmia ribifloris* is an effective pollinator of rabbiteye blueberry. The interior of a completed *O. ribifloris* nest shows cocoons with two open cocoons revealing the developing bee.

and bumble bees there are about 20,000 other species of bees worldwide. The majority of these bees live alone and a female bee is responsible for both building her nest and provisioning it with pollen and nectar. Although solitary bees do not produce workers, they are gaining new respect as crop pollinators for several reasons: they can specialize on certain plant species; they have many unique adaptations for handling flowers; and in many cases, their brief adult life spans can be managed to coincide with crop flowering. Numerous species of solitary bees also have a great potential for commercial management. The best candidates are those species that nest in dense aggregations, readily accept artificial nest sites, and easily awaken from hibernation after a sufficient cold period, thus permitting predictable emergence with bloom. An additional benefit of solitary bees is their gentle behavior around their nests, thus making them safer to handle.

The alfalfa leafcutting bee, *Megachile rotundata*, for example,

has all of these characteristics and has replaced the honey bee as the principal pollinator of cultivated alfalfa in the northwestern United States. Relatives of the alfalfa leafcutting bee, belonging to the genus *Osmia*, also are promising candidates for management because they display the same useful characteristics and some species forage on a variety of crops, including blueberries, almonds, pears, and apples.

An AAES study focused on an iridescent-blue native bee, *Osmia ribifloris* (see Figure 1). Preliminary studies from California and Maine suggest that *O. ribifloris* has considerable potential as a blueberry pollinator. This bee is found from Texas west to California. Adults emerge in early spring, and in the wild, they nest in a wide array of pre-existing cavities.

*O. ribifloris* is being studied as a new pollinator for managed blueberries because it forms large nest aggregations in artificial wood domiciles and its diet in its native range includes close relatives of the rabbiteye blueberry. However, artificially dense nesting populations of any bee are more susceptible to disease and parasitism. Procedures to screen for pathogens and parasitic mites specific to *O. ribifloris* are being developed by the USDA to help ensure the commercial success of the bee by preventing the introduction of this bee's natural enemies.

The goal of this study was to assess the potential of *O. ribifloris* for improving fruit set on rabbiteye blueberry, in light of the advances being made in the management of this bee.

Overwintering adults, still in their cocoons, were shipped in the fall from Austin, Texas, to Auburn. The following spring, 56 female and 36 male *O. ribifloris* cocoons were removed from cold storage and warmed to outdoor temperatures. These cocoons were placed into 7-mm (inside diameter) x 14-cm long waxed paper straws. Straws were inserted into pre-drilled holes in pine blocks. Adult bees emerged into a 14.4 x 9-meter screenhouse, where they were confined with established flowering rabbiteye blueberry bushes. All other bee species were excluded.

The potential of *O. ribifloris* as a blueberry pollinator was evaluated in two ways. First, researchers tested if rabbiteye blueberry leaves and flowers provided enough resources to sustain a small population of *O. ribifloris*. Second, the pollination effectiveness of *O. ribifloris* was gauged by the number of fruit that developed from 553 rabbiteye blueberry flowers visited only by these bees.

Female *O. ribifloris* mated soon after emergence, and 37 of the original 56 females began gathering pollen five days later. Instead of buzzing blueberry flowers, as do bumble bees or the Southeastern blueberry bee, female *O. ribifloris* removed pollen by batting the anthers with their front and middle pairs of legs. Each female transported blueberry pollen back to her nest with the help of a brush under her abdomen. She was also able to reach the sugar-rich nectaries hidden deep inside the rabbiteye flower.

Blue Bees, continued on page 15

# CONSUMER INSIGHTS CAN HELP RURAL RETAILERS INCREASE PROFITS

Evelyn L. Brannon and Lenda Jo Anderson

**T**he ease, acceptability, and frequency of shopping away from hometown stores has increased concern for the survival of small, independent, locally owned businesses in rural towns. However, despite the increasing competition from other shopping alternatives, opportunities exist for these independent retailers to enhance profitability if they understand the tradeoffs consumers use in choosing a shopping destination.

An AAES survey was conducted to determine the relative position of hometown merchants, as compared to other shopping alternatives, in the minds of rural Alabama consumers. The 198 rural consumers surveyed indicated that they most frequently shopped mass merchandisers, such as WalMart or K-Mart. Hometown merchants were the next most frequent choice. Mass merchandisers ranked best in terms of convenience and value for price, but they ranked worst in the area of assortment/selection. Hometown merchants, on the other hand, received the highest ratings for service.

The survey was mailed to residents in six small Alabama towns selected to represent economic and geographic diversity. Subjects were randomly selected from listings for those towns published on a commercial CD-ROM phone directory. Respondents were asked to indicate how frequently they shopped each shopping alternative (mass merchandisers, department stores, specialty stores, hometown merchants, and non-store options like catalogs and

television shopping) on a scale from very frequently (once a month or more) to never. To increase accuracy in the responses, names of well known stores were used to identify the store classifications.

Three shopping alternatives stood out as destinations shopped very frequently (once a month or more): mass merchandisers (64% of respondents), hometown merchants (39%), and traditional departments stores (24%). Shopping venues with the highest percentage of "never" responses were television shopping (88%), career-oriented specialty stores (87%), stores for special sizes (75%), and specialty stores (56%). When reporting occasional shopping (one or two times per year), factory outlets (41%) and catalogs (27%) were selected most often.

Experience and expectations determine consumers' preferred shopping destination. To capture that component of the shopping decision, respondents were asked to rate shopping alternatives from "best" to "worst" on each key attribute — value for price, assortment/selection, quality, convenience, and service.

Over 60% of respondents ranked mass merchandisers highest of all alternatives on value for price (average 6.3 on a 7-point scale) and convenience (average 6.1). The only attribute where mass merchandisers were ranked worse than other shopping

*"It used to be that people would give your small town independent merchants first shot at shopping with them — not any more."*

alternatives was on assortment/selection.

Department stores ranked highest of all alternatives on assortment/selection (average 4.7) and quality (average 5.2). Sixty-five percent of all respondents awarded department stores one of the two top scores on quality.

Fifty percent of respondents awarded hometown merchants the highest score on service (average 5.2). Hometown merchants were ranked second only to mass merchandisers on convenience (average 4.6). On the quality dimension, almost an equal percentage of respondents assigned the best score and the worst score to hometown merchants, showing that groups of consumers may have an opposite experience and differing expectations for the same shopping destination.

One Alabama independent rural retailer summed up the current situation: "It used to be that people would give your small town independent merchants first shot at shopping with them — not any more." Today rural, suburban, and urban customers share similar preferences and choose a particular shopping destination according to their expectations for convenience, price, selection, quality, and service. In this survey, hometown merchants ranked first in service, second in convenience, and third in quality compared to six other shopping destinations. These results show that hometown merchants enjoy a generally positive position in the minds of rural Alabama consumers when compared to other shopping alternatives — a position that can be enhanced through consumer research and competitive analysis.

A "gut feeling" about what consumers expect provides poor support for business decisions made in a competitive climate. Instead, rural retailers must constantly take the consumers' pulse by conducting consumer research. In-store interviews, comment cards inviting candid input, occasional surveys or focus groups can help retailers find out what makes the difference between a satisfied regular customer and an unsatisfied infrequent customer. Even customer complaints can be used to assess how well the retailer is delivering friendly service, accommodating consumers' lifestyles with the right mix of products and services, and providing convenient parking and store hours.

Rural retailers can develop a response plan to stiff competition by shopping the other stores and talking with their customers to identify exploitable weaknesses. In this survey, 67% of respondents gave mass merchandisers the lowest ranking on assortment/selection—an exploitable weakness that hometown merchants can capitalize on by carrying different product lines or more distinctive styles, by offering services coordinated with products, or by marketing locally produced products. Such tactics are essential for survival in a marketplace where consumers have an increasing number of choices in shopping destinations and higher expectations for value, assortment, quality, convenience, and service.

Brannon and Anderson are Associate Professors of Consumer Affairs.

Besides food, blueberry plants provided a female bee with nest-building material. Leaf collecting trips started with a female bee chewing small portions of a leaf into a pulp. Back at the nest, she fashioned this pulp into nest plugs and partitions needed for her offsprings protection (see Figure 2). However, not all sources of leaf material were acceptable. Females preferred smaller and more delicate blueberry leaves, but they also gathered oak and blackberry leaf material.

After only 10 days, females had filled their nest straws with cells. Researchers found that these nests could be protected from predation by ants using Tanglefoot™ barriers. X-ray photos of the interior of *O. ribifloris* nests show that 456 new cocoons were produced; a return of five new cocoons for each bee released. Straws contained, on average, eight healthy pupae (range 0-18 cocoons) indicating that rabbiteye blueberry was a satisfactory host plant for this bee (see Figure 2).

These results also indicate that *O. ribifloris* was an effective pollinator of rabbiteye blueberry. Bushes visited solely by male and female *O. ribifloris* set on average 54 mature berries for every 100 flowers. This is an excellent fruit set for commercial rabbiteye blueberry. As rabbiteye blueberries do not self-pollinate, all of the fruit set can be attributed to this bee. This preliminary study shows that *O. ribifloris* could provide an inexpensive, easily managed, effective, and sustainable solution to the challenges of rabbiteye blueberry pollination in the Southeast.

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## RAPID BACTERIAL TEST HELPS CATFISH PROCESSORS ENSURE FOOD QUALITY

**F**ood-borne disease outbreaks associated with poultry, eggs, milk, and beef in recent years have made consumers more aware of microbial food risks. AAES researchers recently evaluated a simple procedure for detection and enumeration of *E. coli* bacteria on catfish which shortens the testing procedure by seven days. This procedure also can be used for other foods.

There have always been microbial health risks associated with foods because foods are not sterile; even many cooked, ready-to-eat foods are not sterile. Raw, animal-derived foods are particularly susceptible to microbial spoilage and require refrigeration to extend the shelf life and slow microbial growth. Raw foods naturally harbor microbes, just as humans have a natural microbial flora associated with their skin and intestinal tracts. Microorganisms on raw foods are rarely a problem because the foods are cooked before consumption, and when properly cooked, foods are safe.

Food processors abide by strict regulatory guidelines which are enforced by routine inspections to determine compliance with state and federal codes governing "food wholesomeness and safety." Food-borne disease outbreaks in recent years have made regulatory codes for food processors even more stringent. The integrity and national reputation of food processors are strong incentives for processors to do

their best to ensure safe, wholesome food products. Otherwise, they risk regulatory agency sanctions, loss of consumer trust, and possible business failure.

Food buyers for major retail and restaurant chains are establishing their own microbial specifications to ensure that they are purchasing safe,



*Catfish fillets are macerated in sterile phosphate buffered water prior to analysis for E. Coli.*



wholesome foods from food processors. In some cases, the microbial specifications are more stringent than those recommended by regulatory agencies because food buyers want to protect themselves from possible liability from the consuming public.

Another concern for food processors is standardized microbial criteria and standardized testing procedures. There are no mandated microbial standards for raw poultry, beef, pork, and most seafoods, but raw milk has a standard. Microbial populations in excess of set standards indicate that sanitary practices and/or product holding temperatures are inadequate to maintain the desired degree of wholesomeness and safety of the food. Foods with microbial populations in excess of the standards are not permitted for sale.

Although raw poultry, beef, pork, and most seafoods do not have mandatory microbial standards, they



Characteristic green metallic sheen of *E. coli* grown on agar plate.

do have microbial specifications and limits which serve as industry and regulatory guidelines by which acceptable food quality is deter-

mined. Because most raw protein foods do not have mandatory microbial standards, they also do not have standardized testing procedures, which means laboratories conducting microbial analyses can conduct analyses by different procedures, often leading to discrepancies in the test results.

AAES researchers are helping catfish processors to ensure the wholesomeness and safety of their products. Buyers who require the processors to meet microbial specifications sometimes require tests to be conducted more quickly than the lengthy procedures that require a week or more for completion. AAES researchers evaluated two testing procedures for determining the number of *Escherichia coli* bacteria on catfish fillets. The procedures also would be applicable to beef, pork, and poultry.

*E. coli* is associated with humans and warm-blooded animals, and is often used as an indicator for the presence of pathogenic bacteria of fecal origin. Despite the publicity about *E. coli*, it is not generally pathogenic to healthy adults, because all humans harbor the bacterium in their intestinal tracts. Variants of *E. coli*, such as *E. coli* O157:H7, are pathogenic, but they are rarely encountered in the environment and have not been detected on catfish.

Goals of the study were to evaluate a quick, easy procedure and to compare its reliability to a widely

#### Comparison of *E. coli* Enumeration Procedures

Procedure	No. samples	Mean <sup>1</sup>	Range	Days required
Procedure A (FDA 3-tube MPN)	30	1.80	0.3-12	8
Procedure B (EC Petrifilm)	30	1.99	0-25	1

<sup>1</sup> Number of *E. coli* per gram.

accepted FDA procedure. *E. coli* were enumerated by the FDA Most Probable Number (MPN) procedure, referred to as Procedure A in this article. Several steps are required to complete Procedure A, which usually takes about eight days. This standard test was compared to the experimental Procedure B, which used EC Petrifilm (3M Company) in a one-step process that usually can be completed in one day — two days at the most.

Before analyses by the two procedures, 50-gram portions of catfish fillets were placed in sterile plastic bags with 450 milliliters of sterile phosphate buffered water. (One ounce equals 29 grams or 30 milliliters.) These bags were placed in a mechanical agitator called a Stomacher, which agitated and macerated the samples, causing bacteria on the fish to be suspended in the buffered water. The water was then used to enumerate *E. coli* by the two procedures. All samples were analyzed in duplicate by both procedures.

When *E. coli* were enumerated by Procedure B, the counts were not statistically different from those obtained by the standard FDA procedure (see table). The average *E. coli* count for fillets analyzed by the FDA procedure was 1.80 per gram, and the

Rapid Test, continued on page 19

# Plastics from Plants:

## AAES Researchers Implant Tobacco Plants with Synthetic, Biodegradable Polymer Genes

Henry Daniell, Sharon Zhang, Babu Guda, and Dan Urry

**B**iodegradable products are in great demand these days as consumers and manufacturers look for more environmentally friendly products and packages. AAES genetic engineering research has made a giant step toward providing a new, renewable source of biodegradable plastic by implanting a synthetic polymer gene into bacteria and tobacco plants.

Protein-based polymers are naturally occurring polymers that exist in some bacteria as a product of biosynthesis. These polymers can be used to make numerous plastic products, ranging from milk cartons to medical devices. Unlike plastics made from petroleum-based products, protein-based polymers are environmentally safe over their entire

life cycle, from production to disposal. They can be made from renewable resources using water-based processing techniques and are biodegradable. In contrast, petroleum-based plastics are made from exhaustible fossil fuels, require toxic and hazardous chemicals in their production, and are a major problem in solid waste disposal because they do not degrade.

Protein-based polymers also are useful in a variety of other areas. They are remarkably biocompatible, which means they are nontoxic and are readily accepted by organisms. Because of this, they are useful in many medical applications, including the prevention of post-surgical adhesions, tissue reconstruction, and programmed drug delivery. In addition, the polymers have numerous technological applications including: trans-

ducers; molecular machines; super-absorbents; plastic packaging; and controlled release of herbicides, pesticides, and fertilizers.

For protein-based polymers to be commercially viable, however, they must be produced in large quantities and as affordably as petroleum-based polymers that are currently produced. A possible way to accomplish this is to produce these polymers in plants. Traditional row crops, such as corn and soybeans, already are being used to obtain products, such as lipids and oils, for use in industrial applications. If these crops could be used to make biodegradable plastics, the profitability and sustainability of agriculture could be enhanced and, if plants can produce biodegradable polymers as abundantly as plants produce lipids (20-40%

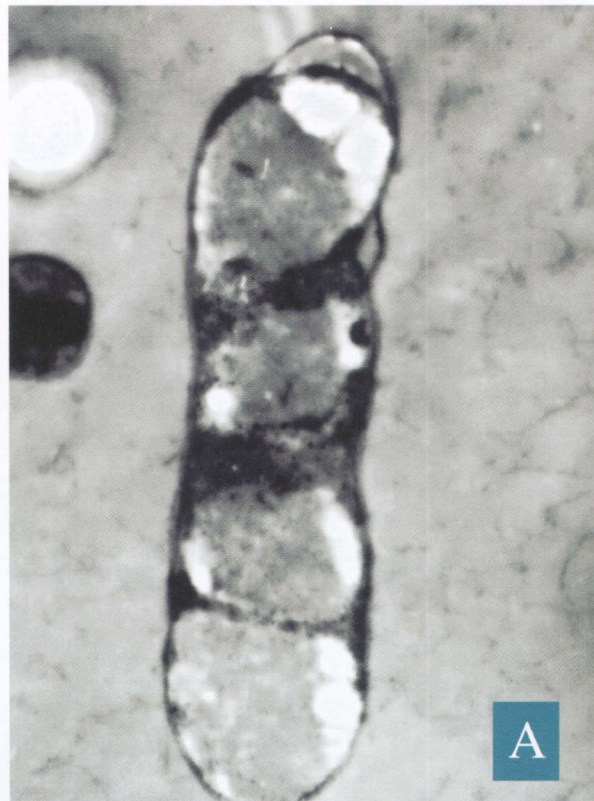


Figure 1A Plastic polymers formed inside a genetically altered E. coli cell.



**B**  
Figure 1B Polymer-like inclusions in genetically altered tobacco leaves.

and resulted in efficient production of polymers inside the bacteria. Some of the genetically altered cells formed single, large bodies of polymers that occupied 70% to 80% of the cell. In other cells, many smaller bodies of polymers occupied 80-90% of the cells (see Figure 1A). On average, a 65-75% area of the fully grown cells was filled with this polymer.

These synthetic genes were then introduced into tobacco cells using the Gene Gun, a device that literally fires genetic material into a cell where it can become part of the cell's genetic structure.

Tobacco was chosen because of its relative ease of genetic manipulation and because concerns about the ill effects of tobacco use may soon limit its current market. If it can be used as a source of protein-based polymers, tobacco growers would have a new use for their crops.

Researchers have successfully incorporated the synthetic gene into tobacco plant cells. This is the first time scientists have demonstrated expression of a synthetic gene (with no natural analog) in plants. Examination of the genetically altered plants showed polymer-like inclusions in tobacco leaves (see Figure 1B).

The next step of the research

average for Procedure B was 1.99 per gram. The target level of *E. coli* recommended by the International Commission on Microbiological Specifications for Foods for fresh and frozen fish is 11 per gram, and the maximum allowable is 500 per gram.

A study was performed to determine if the bacteria enumerated by Procedure B were actually *E. coli*. Of 120 randomly picked colonies from the EC Petrifilm plates used in Procedure B, 119 were identified to be *E. coli*.

Procedure B saves time and labor, compared to the standard FDA procedure, but does not limit accuracy. This test would give food processors an opportunity to analyze their products before shipment to the public.

Hannah is a Research Assistant, McCaskey is a Professor of Animal and Dairy Sciences, and Lovell is a Professor of Fisheries and Allied Aquacultures.

will be to propagate new plants from these genetically-altered plants and determine if the synthetic gene will transmit to new generations. If this occurs, researchers may then be able to implant these and similar synthetic genes into a variety of crops, including row crops and trees, and use these crops to make biodegradable plastics. The result could be a stronger agricultural industry and also a cleaner environment

Daniell is an Associate Professor, Zhang is a Research Associate, and Guda is a Graduate Student in Botany and Microbiology. Urry is a Professor in the University of Alabama at Birmingham School of Medicine.

of dry weight), the polymers could be produced at a cost comparable to vegetable oil (50 cents per kilogram).

Introducing a polymer-making gene into these plants and other organisms has been the focus of an AAES research project. The natural formation of polymers is a complicated process involving several genes that is difficult to duplicate on a commercial scale, so researchers simplified the process by developing a single synthetic gene to implant in bacteria or plant cells.

The synthetic genes were produced in collaboration with scientists at the University of Alabama at Birmingham, then introduced into bacterial cells (*E. coli*, for example) using standard procedures. Results of this phase of the research showed that the synthetic gene was incorporated into the *E. coli* genetic structure

# ROOT-COLONIZING BACTERIA PROMOTE CUCUMBER RESISTANCE TO DISEASE AND INSECT PESTS

G.W. Zehnder, J.W. Klopper, C. Yao, G. Wei, S. Tuzun, R.A. Shelby, O.L. Chambliss, and Jimmy Witt

**AAES** researchers have been evaluating biological control agents as alternatives to pesticides for hard-to-control diseases, such as bacterial wilt of cucurbits caused by the insect-transmitted bacterium *Erwinia tracheiphila*. Bacterial wilt is particularly destructive to cucumbers and muskmelons; squash and pumpkin are susceptible but are not affected as severely.

Fungicides are not effective against bacterial diseases, so the primary control method for bacterial wilt involves use of insecticides targeted against cucumber beetles that spread the pathogen from plant to plant. However, cucumber beetle infestations are impossible to control completely with insecticides because beetles are highly mobile and continually invade cucumber plantings from adjacent fields or weedy areas. In addition, cucumber plants contain a compound called "cucurbitacin" that causes cucumber beetles to feed even more vigorously once they taste it in the cucumber leaves. This cucurbitacin-induced feeding stimulation can cause even greater spread of bacterial wilt by cucumber beetles.

Over the past five years, AAES scientists have been investigating the beneficial properties of specific strains of root-colonizing bacteria, also known as plant growth-promoting rhizobacteria (PGPR), when applied to cucumber as a seed treatment or a root-drench applica-

tion. It is known that certain PGPR strains colonize plant roots following treatment and affect plant physiology in a way that results in increased plant growth and also enhanced activation of the plant's own defense mechanisms against disease. Although the immune systems in plants and animals are very different, PGPR treatment may be thought of as a sort of "vaccination" against plant disease.

Work at Auburn previously demonstrated that PGPR treatment was effective for control of anthracnose disease on cucumbers, caused by the fungus *Colletotrichum orbiculare*. The current study was conducted in 1993 and 1994 to evaluate these same PGPR strains for control of bacterial wilt disease of cucurbits and PGPR's effects on the cucumber beetle vectors of the disease.

Field experiments were done at the E.V. Smith Research Center Horticulture Unit in Shorter, and greenhouse experiments were conducted at the Plant Science Center at Auburn University. In field experi-

ments, PGPR treatments were compared with an insecticide control (weekly sprays with Asana XL™ insecticide) and a nontreated control. In 1993 field experiments, four PGPR strains (86B-61, 90-166, INR-5, and INR-7) were tested; two strains (90-166 and INR-7) were evaluated in 1994. Straight 8 cucumber seeds used in the PGPR treatments were dipped into pelleted bacterial cells before planting.

Cucumber yields from the PGPR-treated plants were higher than yields in the insecticide-treated and nontreated controls in both years of the field experiment (see table). Bacterial wilt symptoms were not prevalent in 1993, but in 1994, the percentage of wilted vines was approximately seven to nine times greater in the nontreated plots compared with the PGPR treatments, and about three to four times greater in the insecticide control plots compared with PGPR treatments. Unexpectedly, numbers of cucumber beetles in the PGPR treatments were not only lower than in the nontreated

**Effect of PGPR Treatment on Cucumber Yield, Cucumber Beetle Numbers, and Bacterial Wilt Symptoms in Field Experiments**

Treatment	Fruit wt.		Cucumber beetles/plant		Wilted vines/plant <sup>1</sup>
	1993	1994	1993	1994	1994
	kg/plot <sup>2</sup>		no.		pct.
86B-61	37.3	NT <sup>3</sup>	0.61	NT	NT
90-166	35.9	28.1	0.44	2.3	2.6
INR-5	32.7	NT	0.56	0.56	NT
INR-7	37.1	26.5	0.73	2.9	3.4
Insecticide control	29.4	21.9	0.89	3.6	11.5
Nontreated	27.3	20.8	1.73	5.4	24.6

<sup>1</sup> Average beetle and wilt values are derived from six replicates, 10 plants per replicate. Beetle data are averaged over six sample dates each year. Wilted vines were recorded on June 24, 1994.

<sup>2</sup> One kilogram equals 2.2 pounds.

<sup>3</sup> NT = not tested.



Figure 1. Reduced beetle feeding on PGPR-treated cucumber stems compared with greater damage on nontreated stems.



Figure 2. PGPR-treated plants on left show little wilt symptoms while nontreated plants are severely wilted.

control treatments, but were lower than numbers in the insecticide control where insecticide was applied on a weekly basis. These results indicate that the PGPR treatments were superior to weekly insecticide applications for control of cucumber beetles and spread of bacterial wilt disease.

Cotyledon leaves from PGPR-treated and nontreated plants were analyzed for cucurbitacin content. This analysis showed that cucurbitacin concentration in PGPR-treated plants was reduced by 16-44%, depending on PGPR strain, compared with nontreated plants. These results suggest that a possible explanation for the lower cucumber beetle populations on PGPR-treated plants is a reduction in the cucumber beetle feeding stimulant cucurbitacin. Previous experiments have demonstrated that cucumber beetles can detect cucurbitacin in amounts as small as a billionth of a gram. Therefore, it is likely that cucumber beetles in the field can discriminate among plants with varying cucurbitacin concentrations.

A series of greenhouse experiments was done in which cucumber beetles infected with the bacterial wilt pathogen were released to feed on plants inside screen cages to prevent beetle escape. Experiments were designed two ways: (1) choice experiments in which beetles were free to feed on both PGPR or nontreated plants in the same

cage, and (2) no-choice experiments in which beetles were confined in a cage with either PGPR-treated or nontreated plants.

In both designs, beetle feeding on cotyledons and stems of PGPR-treated plants was significantly lower than on nontreated plants (see Figure 1). Wilt symptoms on plants in cages were first observed five to seven days after release of the infected beetles; experiments were run for 17-23 days after beetle release, after which the plants were examined for signs of wilt.

In both the choice and no-choice experiments, the average numbers of wilted leaves per plant were significantly lower on PGPR-treated plants compared with the nontreated plants (see Figure 2). These results demonstrate that spread of bacterial wilt by cucumber beetles is significantly reduced by PGPR treatment, even if beetles are restricted to feeding only on PGPR-treated plants.

Another series of experiments was done in which the bacterial wilt pathogen was inoculated into PGPR-treated and nontreated plants without cucumber beetles (artificial inoculation). Plants were examined for wilt symptoms 23 days after inoculation. The average numbers of wilted leaves per plant were significantly lower on PGPR-treated plants compared with nontreated, indicating that PGPR protect plants from infection even if beetles

are not involved in transmission.

Based on these results, it appears that PGPR-induced protection against bacterial wilt disease works on two levels. First, PGPR protects the plants against cucumber beetle feeding, thereby reducing spread of the disease. This feeding reduction probably is linked to reduced levels of cucurbitacin in PGPR-treated plants. The second level of protection occurs after the pathogen is introduced, and is manifested as plant resistance or tolerance to bacterial wilt infection.

PGPR treatment of crops by seed treatment or transplant drench application represents an exciting, new, and environmentally friendly tool for use in pest management. While most biological control agents have activity against a narrow spectrum of pests or pathogens, a key advantage of PGPR is that PGPR-induced resistance may lead to protection against a wide spectrum of pathogens and/or pests. This was demonstrated in AAES experiments, where two diverse pests (a bacterial pathogen and an insect) were controlled by PGPR.

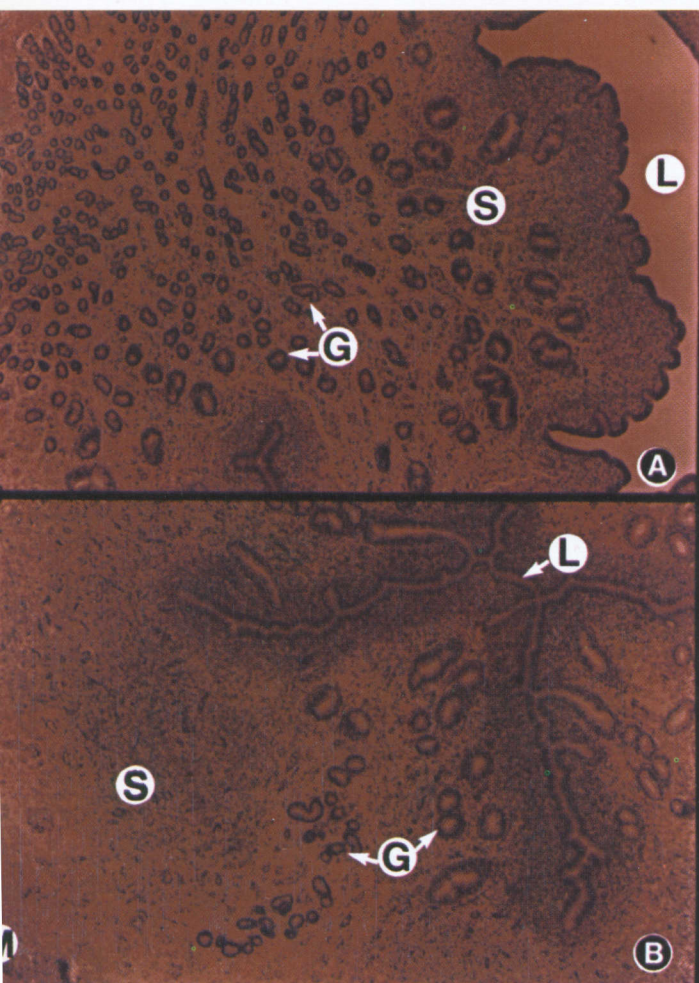
Zehnder is an Associate Professor and Yao is a Graduate Research Assistant in Entomology. Kloepper is Department Head and a Professor; Wei is a Postdoctoral Fellow, Tuzun is an Associate Professor; and Shelby is a Research Fellow in Plant Pathology. Chambliss is a Professor of Horticulture and Witt is Superintendent of the E.V. Smith Research Center Horticulture Unit.

# Beef Herds Can Benefit From Wise Use of Implants

Frank F. Bartol, James G. Floyd, Jr., Dale A. Coleman, Anne A. Wiley, and Donald F. Buxton

**G**ROWTH PROMOTING IMPLANTS are among the most cost effective management tools available to the beef cattle producer. Implanted calves typically weigh about 15-20 pounds more at weaning than nonimplanted calves. However, previous research involving laboratory animals has shown that the same hormones used in growth-promoting

Photographs illustrate the microscopic structure of the wall of the adult (15 months old) uterus in a normal, nonimplanted control heifer (A), and a heifer that received an implant on the day of birth that released both progesterone and estradiol for approximately 200 days (B). Note marked loss of uterine glands (G) due to hormone exposure in (B). S = uterine stroma (connective tissue), M = myometrium (muscle), L = uterine lumen (interior).



implants (progestins and estrogens), when given very early in life, alter the structure and function of adult reproductive tract tissues. This includes the uterus, an organ responsible for maintaining pregnancy. Furthermore, the sooner following birth that these animals were exposed to the hormones, the more severe the problems. Critical periods of exposure, during which administration of certain hormones to heifer calves might affect development of reproductive organs and fertility in adults, have not been defined.

In cattle, the uterus is not completely developed at birth. The wall of the uterus, which includes the lining (endometrium) and

More detailed data and information about this study can be found in *Theriogenology* (1995) 43:835-844.

the muscular layer (myometrium), undergoes dramatic structural changes during the first three months of life when uterine glands form in the endometrium and uterine musculature increases. Interruption of these events, during early critical developmental periods, could cause reproductive problems in cattle similar to those recognized in laboratory animals. Such changes might limit the ability of the uterus to support pregnancy in adult heifers.

Controlled studies of the long-term effects of hormone exposure during early life on subsequent adult uterine structure and function have not been reported in cattle. Therefore, an AAES study was instituted to determine if exposure of heifer calves to specific implant hormones, beginning between birth and earliest labeled use (45 days of age), would affect adult uterine structure or protein content of uterine fluid and whether these effects would be related to the age of the calves when hormone exposure began.

Twenty crossbred heifer calves of similar genetic background were assigned to one of four treatment groups (five calves per group) defined by the age of calves when they received a Synovex-C growth-promoting implant. Synovex-C treatment consists of four pellets designed to release progesterone (P, 100 mg) and estradiol benzoate (E, 10 mg, long-acting estrogen) for about 200 days.

Three groups of calves were implanted on either the day of birth, or at 21 or 45 days of age. Calves in

**IN ONGOING RESEARCH BY  
THE AAES, THE FOLLOWING  
STRATEGIES HAVE PROVEN MOST  
SUCCESSFUL WHEN USING  
IMPLANTS IN HEIFER CALVES**

▶ *Implant all heifers to be sold as feeder calves (not intended for use as replacements) according to label directions.*

▶ *If a heifer is likely to be used as a breeding replacement, there is no need to implant her.*

▶ *If heifers are not selected as replacements until weaning, implant only those born after the birth of a sufficient number of potential replacements.*

▶ *Implant all heifers according to label directions but retain and breed more replacements to compensate for any potential negative effects on pregnancy rates.*

the fourth group were not implanted and served as controls. Day 45 was chosen because it is the earliest age at which this implant is approved for use in heifers intended for reproduction. Birth was chosen because hormone exposure would occur prior to the onset of rapid growth of uterine glands, and previous studies indicated that consequences of early hormone exposure might be severe. Day 21 was chosen as an intermediate day between birth and 45 days of age when uterine tissues are maturing.

All heifers were kept together, weaned at 205 days of age, and maintained on pasture at the Piedmont Substation (Camp Hill). Heifers were allowed to reach puberty, and the reproductive tract was removed from each heifer on day 12 of an estrous cycle when they were approximately 15 months of age.

Each reproductive tract, including both the uterus and cervix, was weighed, and uterine fluids were collected to test for protein content (uterine "milk"). Crosssections of the uterus were examined to evaluate development of the uterine wall, where an embryo would normally attach and be sustained during pregnancy.

Results are shown in the table. Regardless of the age at which calves were implanted, exposure to P and E reduced the combined weight of the uterus and cervix by 35%, endometrial area by 27%, and myometrial area by 23%. Endometrial gland density, an estimate of the number of uterine glands per unit area of

endometrium, also was reduced by 40% in implanted heifers. This effect was clearly related to the age at which calves were implanted. Endometrial gland density was reduced by 65% in heifers implanted at birth, while reductions of 22% and 33% were observed for heifers implanted on either day 21 or day 45. Consistent with the reduction in endometrial area and gland density, protein content of uterine fluid was reduced by 46% in implanted heifers.

Photographs in the figure,

taken through a microscope, show the normal structure of the adult uterine wall in a nonimplanted control heifer (A) compared to that of a heifer that was implanted at birth (B). Note the abundance of endometrial glands (marked G in the figure) in nonimplanted heifer (A) compared with the large area without glands in implanted heifer (B). Results indicate that exposure of calves to P and E, beginning between birth and 45 days of age, does affect adult uterine structure and protein content of uterine fluid and does alter adult endometrial anatomy. Furthermore, effects were more dramatic the earlier that exposure began.

Clearly, neither treatment-induced structural changes in uterine tissues, particularly those

identified in heifers first exposed to P and E at birth, nor reduced uterine fluid protein content are desirable effects in heifers intended for reproduction. Since both maternal uterine tissues and uterine fluids play important roles in support of embryo development, these results provide a potential explanation for reduced fertility observed in some heifers implanted outside of label directions. However, the potential for uterine

**Implants, continued on page 24**

changes observed in this study to affect pregnancy rate in adult heifers remains to be investigated.

The fact that exposure of newborn calves to P and E had such profound effects on adult uterine anatomy indicates that biological processes affected by these hormones early in life regulate patterns of uterine development. Therefore, these hormones, and other drugs that affect their action, may be useful tools with which to identify mechanisms that regulate development of the uterine wall. It will be important to identify these biological processes and to determine the extent to which the success of developmental events that occur shortly after birth may dictate the capacity of uterine tissues to function properly.

Overall, beef herds can benefit from the wise use of growth promoting implants to increase pounds of gain and improve body composi-

tion. The proper and aggressive use of growth-promoting implants can enhance the efficiency and profitability of beef production and should be encouraged. However, this study shows that careful management is vital to ensure that cattle producers reap the benefits of these implants while avoiding reproductive complications in replacement heifers. Research summarized here reinforces the importance of following label

guidelines for use of implants, provides justification for continued efforts to develop and refine guidelines for the use of these important tools, and sets the stage for new studies designed to identify developmental factors that affect reproductive efficiency in cattle.

Bartol, Floyd, and Coleman are Associate Professors and Wiley is a Research Associate in Animal and Dairy Science. Buxton is a Professor of Anatomy and Histology.

**Effects of Progesterone and Estradiol Exposure Beginning on or After Birth (Day 0) on Uterine Structure and Uterine Fluid Protein Content in Adult Beef Heifers**

Responses	Age at Implanting				SEM
	Birth	Day 21	Day 45	Control	
Weight of uterus and cervix (grams)	113.7	123.5	101.3	173.9	13.9
Myometrium (mm <sup>2</sup> )	123.7	141.8	111.3	162.8	8.5
Endometrium (mm <sup>2</sup> )	29.9	32.4	37.7	45.4	2.7
Uterine gland density (units/mm <sup>2</sup> )	172.2	380.3	328.2	486.9	48.6
Uterine fluid protein content (mg)	2.8	2.9	2.3	4.9	0.7

Hormones delivered using the Synovex-C implant. Data represent mean values of five heifers per group. SEM = Standard Error of the Mean.

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