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HIGHLIGHTS

OF AGRICULTURAL RESEARCH

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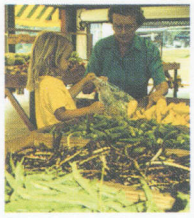

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ON THE COVER. The Old Rotation, established in 1896, continues to provide information for Alabama's cotton industry. See stories on pages 11 and 13.

from the Director

The proverb, *The best way to kill time is to work it to death*, is very appropriate for the Alabama Agricultural Experiment Station (AAES). Although 10 years have passed since I became the Director of the AAES, it seems like only yesterday. Each day brought new and interesting challenges. A dedicated faculty and staff helped to make this 10-year period most enjoyable for me and time passed ever so quickly. We worked it to death.

Much has been accomplished and many unfinished tasks remain. The goal of the AAES has been and always will be to serve the people of Alabama. Our research program reflects this goal. Alabama's natural and human resources provide the base for the expansion of its agricultural and forestry industries.

Time nor space does not permit me to thank everyone for their support. The various commodity, industry, and other organizational groups have been very supportive of the AAES. I am convinced that this support will continue into the future. The AAES is an important contributor to the health and well-being of the State and your advice and counsel are needed.

Life without a friend is death without a witness. During my tenure, I have made many new friends. In the coming years when I reflect on our acquaintances, a smile will appear on my face. Thank you for your guidance, counsel, and, most of all, your friendship. I have many friends!

Lowell T. Frobish

EDITOR'S NOTE: Effective October 1, Dr. Frobish will join the faculty of the Department of Animal and Dairy Sciences.

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

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Alternative Production Method Feasible for Landscape Nurseries

Alabama's nursery industry has experienced dramatic growth in recent years to become a market-driven system generating substantial economic activity characterized by diverse product sizes, types, and forms. Increased competition has caused producers and users of landscape products to seek ways to improve efficiency. An alternative production method, the pot-in-pot system, has received attention because it offers several advantages over conventional systems.

John L. Adrian, Chris C. Montgomery, Bridget K. Behe, Patricia A. Duffy, and Kenneth M. Tilt

To evaluate the feasibility of this alternative production system, AAES economists and horticulturalists conducted an economic analysis of pot-in-pot production, compared to the conventional methods of in-field and above-ground-container production. Overall, pot-in-pot production seems to be a viable alternative, especially for small nurseries.

With the pot-in-pot system, liners (young plants) are transplanted into pots filled with soil-less media, similar to the above-ground system. However, instead of placing these pots into a holding area on top of the ground, they are placed into second containers of the same size, known as socket pots. Before the insert pots are added, socket pots are buried in the ground with only the top two or three inches protruding above the soil. Plants are then grown to desired sizes and marketed in the insert pots. In above-ground production, the containers remain on top of the ground, while with in-field production, liners

Alternative Production, continued on page 4

Comparisons of In-field, Above-ground-container, and Pot-in-pot Production Systems[1]

Variables	Production System		
	In-field	Above-ground	Pot-in-pot
Capital requirements	$194,840	$194,820	$207,100
Machinery, equipment operation costs	$13,185	$8,280	$7,850
Total variable cost	$48,895	$78,825	$63,840
Variable costs per harvested plant	$5.15	$6.99	$4.94
Total fixed costs[2]	$344,505	$333,810	$361,110
Fixed costs per harvested plant	$18.14	$14.80	$13.97
Total costs	$393,400	$412,635	$424,950
Total costs per harvested plant	$23.29	$21.79	$18.91
Plants produced[3]	18,988	22,562	25,858

[1] These figures are based on computer simulations of a 15-acre nursery with 10 acres in production on a three-year growing cycle for crapemyrtle using current best management practices.
[2] Includes $24,040 per year ($72,120) imputed to cover the owner-operator s contribution.
[3] Assumes a 5% per year loss rate. All plants are grown to 10-gallon size for above-ground and pot-in-pot production systems. In in-field production, plants are grown to six to seven feet with a 1.5- to two-inch caliper; plants are harvested, and the root ball is wrapped in burlap material.

are transplanted directly into the soil.

Costs were evaluated for a 15-acre nursery with a 10-acre production area on a three-year growing cycle for production of crapemyrtle. Cost estimates were derived from southeastern commercial operations that use the various production methods, estimates from horticultural researchers, and existing budgets for container nurseries. Using this information, along with other variables that are considered the best management practices for the industry, researchers analyzed the relative feasibility of each production practice. Collecting these data was a preliminary step toward programming a computer model to perform an in-depth analysis of the nursery industry.

In-field production included primary and secondary soil tillage of the ten acres, followed by fertilization based on soil test recommendations. Bare-root liners were purchased and planted, and a drip irrigation system was used to provide water and fertilizer. Plants were scheduled for harvest in the winter of the third growing season.

Above ground container production began with propagation of cuttings in one-gallon containers and growth for one year in polyethylene-covered greenhouses. Plants were then transplanted to three-gallon containers and moved outside where overhead irrigation was utilized. After another year, plants were transplanted to 10-gallon containers and were staked using three-foot sections of rebar, or metal stakes. Plants were harvested during the third spring.

Pot-in-pot production used the same initial cutting procedure for propagation and cultural practices as above-ground production. However, plants were transplanted directly from one-gallon to 10-gallon containers. Elimination of the three-gallon stage allowed a larger number of plants to be produced. Also, no stakes were needed since placing the socket pots in the ground provides all the support necessary. This system also requires less labor and equipment. A drip irrigation system was used to water and fertilize the plants. Plants were harvested in the spring after two years of growth in the 10-gallon containers.

Most equipment (tractors, trucks, sprayers, etc.) was the same for all three production methods. Essential equipment for in-field production was a moldboard plow, disking harrow, single-row transplanter, and a tree spade. Improvements on the production area, including such items as grading, tree removal, and building access roadways, waterways, and holding ponds were estimated at $1,200 per acre for the in-field system, $3,670 for above-ground, and $1,429 for pot-in-pot.

Of the total capital requirements (see table), land and improvements accounted for 13% of in-field system expenditures; 20%, above-ground; and 14%, pot-in-pot. Buildings accounted for 18% for in-field production; 25%, above-ground; and 23%, pot-in-pot. Machinery and equipment added another 69% to in-field costs; 55%, above-ground; and 63%, pot-in-pot.

The pot-in-pot system had the highest initial total capital and total fixed costs levels (see table) primarily because of higher costs associated with purchasing and installing the socket pots. Other disadvantages of this system include potential drainage problems within socket pots and the possibility of root elongation into the socket pot and surrounding soil. Also, containers may stick together, and the insert pot bottom may sag, causing an uneven base. However, this system generated the lowest per-plant cost because of less-intensive, labor-saving cultural practices and the ability to grow more plants on the available space. Total cost per harvested plant was $18.91 for the pot-in-pot system, compared to $23.29 for in-field and $21.79 for above ground.

Pot-in-pot production offers several advantages over above-ground-container production. For example, the root-zone is insulated from extreme temperature variations, the plants remain in place throughout the winter, trickle irrigation reduces water usage, and extensive staking is eliminated.

When compared with in-field production, the pot-in-pot system is superior in terms of year-round harvest capability, reduced harvest labor cost, and decreased root loss at harvest. Also, in shipping and handling, pot-in-pot material is less bulky and cumbersome than in-field-produced material.

Adrian and Duffy are Professors of Agricultural Economics. Montgomery is a former Graduate Research Assistant, Behe is an Associate Professor, and Tilt is a Professor of Horticulture.

Cockroach Control Methods Can Cause Other Pest Problems

Lane M. Smith,
Arthur G. Appel,
and Gary J. Keever

Traditional cockroach control methods can upset the balance between beneficial and nuisance insects. Research showed that treatment can increase some pest populations, while decreasing numbers of beneficial insects and spiders.

AAES researchers have found that traditional pest control methods targeted against smokybrown cockroaches can greatly increase abundance of other nuisance insects. Furthermore, traditional treatments can also reduce populations of beneficial insects that prey on pests.

Smokybrown cockroaches are the main outdoor-nuisance pests around Alabama homes. Traditional efforts to control cockroaches were shown to significantly increase populations of other pests, such as Argentine ants, fire ants, acrobat ants, and small black ants. In addition, these pesticide treatments reduce numbers of beneficial predators — such as jumping spiders and ground beetles — which are natural enemies of pests that feed on grass, bushes, and trees.

However, an AAES-developed integrated pest management (IPM) program for smokybrown cockroaches only slightly increased abundance of some pests, while also slightly increasing abundance of some beneficial insects. The IPM treatment includes strategic applications of gel and pellet baits to mulch, wood piles, aluminum sheds, crawl space gratings, and other outside spots where cockroaches are likely to hide and eat. Previous research showed that the IPM system is not only more effective than the traditional pesticide sprays applied in a perimeter around the house, but it also reduces the amount of pesticide needed by up to 90%.

At 107 houses in Lee County, researchers compared the IPM treatment to no control and to the perimeter spray cockroach treatment, which is applied in a 10-foot swathe around the house. Special baited traps were used to capture cockroaches in order to gain information about changes in cockroach numbers. These traps also collected about 30 different types of other insects or spiders. Insects were sampled six times from July through September. Researchers compared the numbers of insects and spiders captured at homes receiving the various treatments.

IPM and perimeter treatments reduced the abundance of smokybrown cockroaches, as well as some other pests, such as camel crickets (see table). But American cockroaches and native

Cockroach Control, continued on page 6

woods cockroaches were not controlled. Homeowners cannot expect to control all pests by applying methods designed for use against smokybrown cockroaches. Abundance of the beneficial daddy-long-legs was reduced by both treatments, but the beneficial crab spider was unaffected by either.

Several house-infesting insects were more abundant at homes where cockroach control treatments were used. Numbers of Argentine ants, fire ants, acrobat ants, and small black ants increased, compared to homes where no pesticides were applied. This response by ants may result from the scavenging of dead insects left after application of the two treatment methods. Nevertheless, increased ant activity near homes might lead to greater human contact with these pests and greater perceived problems.

When viewed in terms of species composition (see figure), homes treated with perimeter sprays had a greater relative percentage of Argentine ants, fire ants, and field and house crickets. While IPM-treated homes also had more ants, these pests were much more abundant at homes treated with perimeter sprays. Jumping spiders and ground beetles were reduced at homes receiving the perimeter spray, but IPM-treated homes had a much greater relative abundance of these beneficial predators.

Even if the population of a given insect or spider increases, that does not necessarily mean they will increase to problem levels. The actual size of a decrease or increase of beneficials or pests caused by treatment depends on the abundance of insects present before treatment. Homes with initially low pest abundance would not experience as big an increase as houses with initially high pest abundance.

A problem with assessing the treatments is that some insects prefer certain environments, and thus are more likely to be found at some homes, regardless of whether any cockroach treatment methods are used. For example, Argentine ants appear to prefer open lots without trees, whereas native woods cockroaches prefer wooded lots. Lots with a few trees have different insects associated with them. Researchers accounted for these differences by statistically factoring out the effect of tree abundance. Trees are not the only environmental factor around homes, but the AAES analysis showed they do provide an explanation for the distribution of some insects and spiders. Even after correcting for this environmental difference, researchers still detected the differences in relative abundance of pests and beneficials between the two treatment methods and no control.

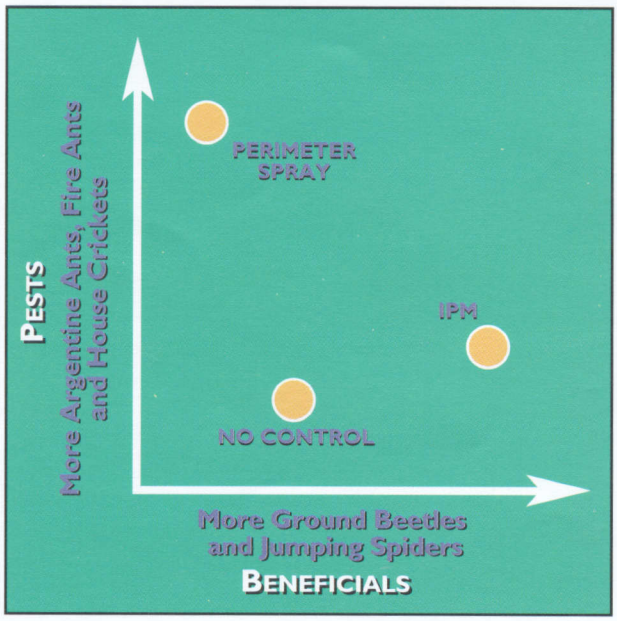
Perimeter sprays reduced the abundance of some pests by 10-30%, compared to 75-95% for smokybrown cockroaches. Unfortunately, they also increased the abundance of some pests 10-30%. Perimeter sprays have the potential for increasing other pest problems by reducing the abundance of beneficial insects and spiders. These studies show that besides using less pesticide, and providing good control, IPM has less impact on other pests and beneficials in the urban environment.

Change in Abundance of Other Arthropods in Urban Yards Affected by Control Measures Against Smokybrown Cockroaches

Types of arthropods[1]	Change in abundance[2]	
	Perimeter spray	IPM program
American cockroaches	+7%	-16%
Argentine ants	+19%	+5%
Big red-headed ants	-9%	-5%
Camel crickets	-12%	-12%
Carpenter ants	+30%	+41%
Crab spiders	0%	0%
Daddy-long-legs	-11%	-9%
Earwigs	+13%	-4%
Field and house crickets	-5%	-3%
Fire Ants	+20%	+15%
Ground beetles	-14%	+3%
Native woods cockroaches	0%	-8%
Other spiders	-11%	-7%
Pill- and sowbugs	-15%	-2%
Wolf spiders	-34%	+40%

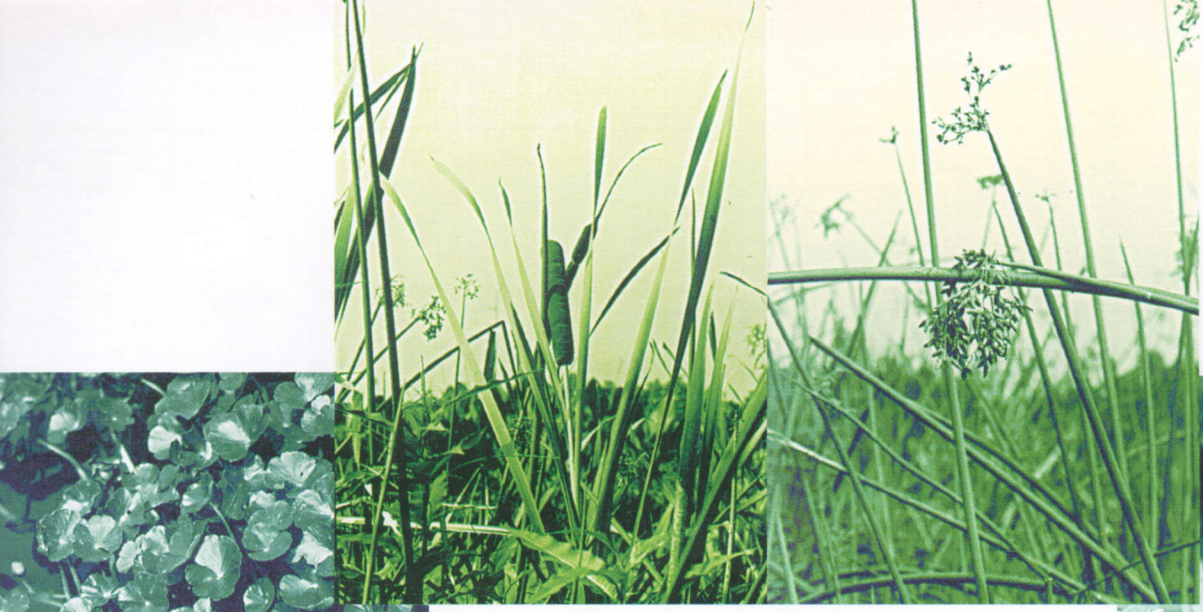
[1]Arthropods include a wide variety of invertebrates, including insects, arachnids, and crustaceans. The 15 most commonly trapped arthropods are listed in this table.

[2]Positive numbers indicate increased abundance at homes treated with the listed method, while negative numbers indicated decreased abundance, relative to no control.



Points in the diagram show the average relative change in abundance of pests and beneficials caused by each treatment. The perimeter spray had a much higher relative abundance of pests than the IPM or no control treatments. The IPM treatment had a higher relative abundance of beneficials than no control, and the perimeter spray treatment had fewer beneficials than the no control treatment.

Smith is a Post-Doctoral Fellow and Appel is a Professor of Entomology. Keever is a Professor of Horticulture.



Wetlands plants (clockwise from left): pennywort, cattail, bulrush, and bulltongue.

Constructed Wetlands Transform Raw Sewage into Pond Water

Rachel M. Krotz, Thomas A. McCaskey, Sheng D. Zhou, Sarah Lino, R. Anthony Dawkins, and Marvin E. Ruf

Constructed wetlands, planted with aquatic vegetation such as cattails and bulrush, are an effective, natural, and inexpensive wastewater treatment system for livestock and poultry production facilities. AAES researchers, in cooperation with the Tennessee Valley Authority, have studied such a system since 1989 at the Sand Mountain Substation in Crossville.

Since its construction, this wetland has continuously treated swine lagoon wastewater from a 500-pig-per-year, farrow-to-finish operation. AAES researchers have completed six years of study on the relative sustainability of various water plants used in the wetland and the ability of these species to take up wastewater contaminants. Results show that bulltongue, soft rush, and common cattail are the best species for use in constructed wetland plantings. A mixture of these species can be used to overcome the limitations of each.

Constructed wetlands are shallow earthen basins planted with aquatic vegetation. By a process called phytoremediation, pollutants in the wastewater are removed by plants in a symbiotic association with beneficial soil bacteria. Plants transport oxygen from their leaves to their roots, where oxygen-dependent bacteria are colonized. These bacteria convert nitrogen-containing organic wastes into ammonia, which is then oxidized to nitrate. Ammonium and nitrates, as well as the phosphorus and potassium contained in the wastewater, are taken up by the plants and used as nutrients.

Sand Mountain's wetland was constructed in 1988 as a two-tiered system with five, one-tenth acre cells in each of the upper and lower tiers. About 6,200 gallons of effluent per day flow into the upper five cells. Water flows the length of these cells before it flows into and across the lower tier of cells. It takes about 18 days for the water to flow through both tiers. Water treated in the wetlands meets criteria recommended by the Natural Resource Conservation Service.

In 1989, several types of aquatic vegetation were planted in the wetland cells. After natural selection pressures such as insect pests, severe winter freezes, invading plants, and dominance by some species, nine predominant plants have emerged (see tables). Each cell contains a mixture of these plants. Recent studies have focused on these nine plants yield of vegetative material (biomass) and ability to uptake nitrogen, phosphorous, and potassium (N-P-K). During June of 1994 and 1995, at peak maturity of the plants, samples of shoots and leaves of the dominant plants were cut and ana-

Constructed Wetlands continued on page 8

Table 1. Dry Matter, Carbon, Nitrogen, Phosphorus, Potassium, and C:N Ratios of Wetland Plants[1]

Plants	DM	C	N	P	K	C:N ratio[2]
	pct.	*pct.*	*pct.*	*pct.*	*pct.*	
Pennywort	5.8	41.6	3.06	0.78	5.57	13.6
Bull-tongue	9.1	46.5	2.86	0.56	5.14	16.3
Common Cattail	15.2	49.4	1.85	0.50	3.11	26.7
Narrowleaf Cattail	18.8	49.2	1.93	0.34	2.94	25.5
Common Bulrush	18.6	50.0	1.82	0.36	3.14	27.5
Giant Bulrush	15.5	47.0	1.65	0.42	3.27	28.5
Soft Rush	31.5	52.3	1.60	0.24	2.63	32.7
Giant Cutgrass	20.5	50.3	2.44	0.28	3.11	20.6
Rice Cutgrass	24.5	49.7	2.05	0.42	2.15	24.2

[1]Data represent averages of samples collected in June of 1994 and 1995. Dry Matter = DM; Carbon = C; Nitrogen = N; Phosphorus = P; Potassium = K. Percent N, P, and K were determined on dry weight basis.

[2]C:N ratio is the amount of carbon units per unit of nitrogen. The beneficial soil bacteria important in treating wastewater requires a certain amount of carbon to survive, usually a C:N ratio of at least 25:1. All but four of the wetland plants had a C:N ratio of 25:1 or higher.

Table 2. Harvestable Dry Matter, Nitrogen, Phosphorous, and Potassium in Wetland Plants

Plants	DM	N	P	K
	tons/a.	*lb./a.*	*lb./a.*	*lb./a.*
Pennywort	4.9	300	76	546
Bull-tongue	11.7	669	131	1,203
Common Cattail	11.8	437	118	734
Narrowleaf Cattail	12.1	467	82	711
Common Bulrush	9.4	342	68	590
Giant Bulrush	5.8	191	49	379
Soft Rush	19.2	614	92	1,010
Giant Cutgrass	11.6	566	65	722
Rice Cutgrass	7.9	324	66	340

lyzed (Table 1).

The ability of a plant to remove N-P-K from wastewater is determined by two factors: (1) its yield of biomass, and (2) the amount of the three nutrients it takes up. When both these factors are considered together, bull-tongue is the most efficient plant at removing N-P-K. Bull-tongue had only a moderate yield, but its relatively high content of N-P-K compensated. In one growing season, bull-tongue removed 669 pounds of N, 131 pounds of P, and 1,203 pounds of K per acre of wetland (Table 2). One weakness of bull-tongue is its relatively low carbon-to-nitrogen ratio (C:N ratio). Carbon is needed to sustain beneficial bacteria in the wetland. However, the other highly efficient plants — soft rush and common cattail — provide relatively high amounts of carbon.

Soft rush had the highest yield of biomass and was relatively effective at accumulating nutrients, making it a close second to bull-tongue in terms of N-P-K removal. Common cattail and giant cutgrass were also among the better performing plants, in terms of biomass production and N-P-K accumulation. Bull-tongue, soft rush, and common cattail were also top performers in terms of survivability and density of plants.

Plants in the Sand Mountain constructed wetlands have never been harvested. One long-range goal of the study is to determine how long a wetland can function without harvesting to remove nutrients trapped in the system. Although N removal by harvesting the plants would be beneficial, there are other natural mechanisms that remove this nutrient, such as its release as nitrogen gas. Phosphorus, which is not volatile, eventually must be removed from the wetland in order to preserve its long-term sustainability as a wastewater treatment system. The best accumulators of P were bull-tongue, common cattail, and soft rush. So far, the wetland does not seem to be overloaded with nutrients.

March-June is the most active growing period for the plants. During this time, plants retained 61.3% of the nitrogen and 40.1% of the phosphorous that had originally flowed into the system from the swine lagoon (Table 3). Plus, the water and soil in the wetland retained another 19.6% of the nitrogen and 40.2% of the phosphorous during these months. There is little or no plant growth or uptake of nutrients for about five months, thus the annual removal rate of N-P-K is somewhat less than March-June. When measured from June to June, only 22% of the nitrogen and 12.6% of the phosphorous flowing into the wetland were retained by the plants. Another 52.3% of the nitrogen and 55.6% of the phosphorous were retained in the wetland soil and water over the course of a year.

These data indicate that aquatic plant species play a significant role in wastewater treatment in constructed wetlands. Since 1989, the Sand Mountain wetland has consistently converted what is essentially raw sewage into water of the same quality found in most farm ponds.

Krotz is a Research Associate, McCaskey is a professor, Zhou is a Graduate Research Assistant and Lino is a Research Specialist in Animal and Dairy Sciences. Dawkins is Supervisor of Herd Research and Ruff is Interim Superintendent of the Sand Mountain Substation in Crossville.

Table 3. Nitrogen and Phosphorus Distribution in Wetlands and in Wetland Plants

	March-June[1]				Avg. year[2]			
	N		P		N		P	
	lb./a.	*pct.*	*lb./a.*	*pct.*	*lb./a.*	*pct.*	*lb./a.*	*pct.*
In inflow	473.7	100	145.3	100	1320.6	100	461.7	100
In outflow	90.4	19.1	28.6	19.7	339.7	25.7	147.0	31.8
Retained in wetland[3]	383.3	80 .9	116.7	80 .3	980.6	74 .3	314.7	68.2
Retained in plants[4]	290.4	61.3	58.2	40.1	290.4	22 .0	58 .2	12.6

[1]March-June is the most productive time for the water plants, and thus the time when they take up the most nutrients. These figures are the averages for 1994 and 1995.

[2]These are averages for 1993-94 and 1994-95 and are measured from June to June.

[3]Nutrients retained in the wetland are either taken into the plants, bound to the pond soil, or remain in the water.

[4]Figures in this row report the average nutrients contained in the plants evaluated. This information is one portion of the data included under the previous heading Retained in wetland. For example, the March-June section reports that 80.9% of the nitrogen was retained in the wetland, while 61.3% was retained in the plants themselves. This means that 19.6% of the nitrogen was retained in the wetland soil and water.

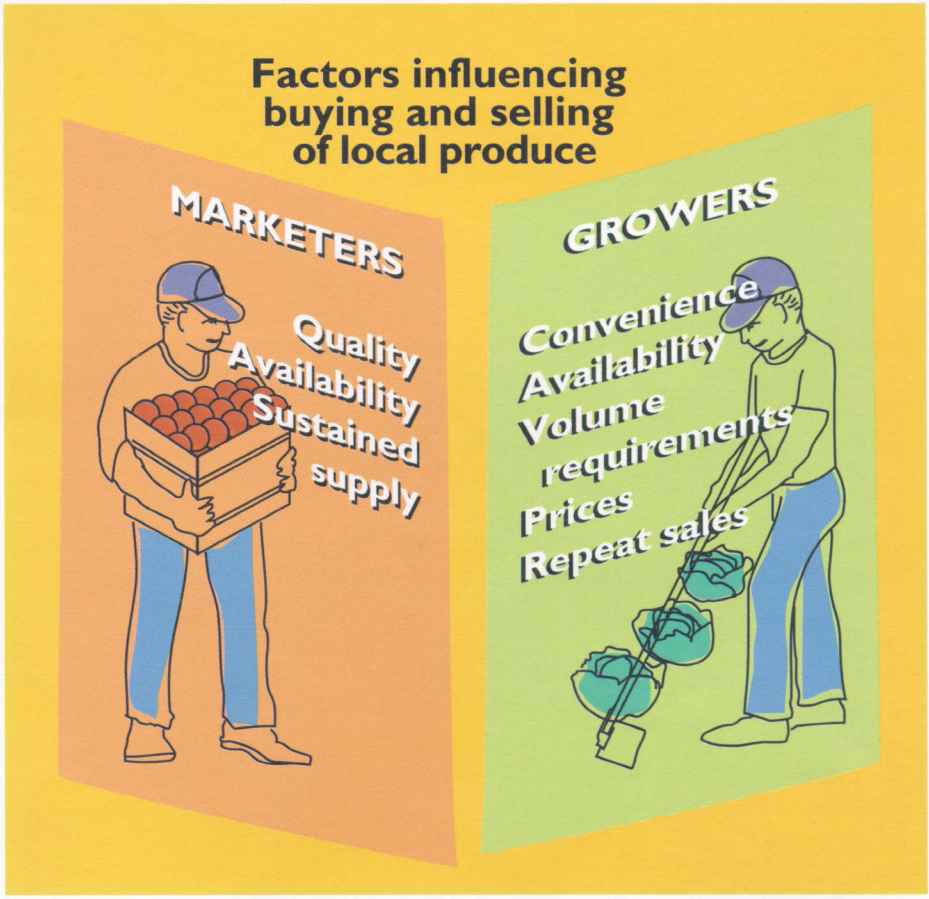
Produce it, and they will come???

John L. Adrian, Stephen L. Kiser, and Stephen R. Frazier

When an other-worldly voice commanded Kevin Costner to "Build it, and they will come," he was rewarded with his *Field of Dreams*. Unfortunately, no such optimistic spirit has communicated with Alabama's fruit and vegetable producers. If one did, it might say, Produce it, but they may not come.

In reality, a frequently heard comment among produce growers is, We can grow it, but we can't sell it. Recent efforts by AAES economists have attempted to evaluate this professed dilemma and provide some insight into the problem. Their study indicated that future growth of Alabama's commercial fruit and vegetable sector will be greatly influenced by better coordination between growers and marketers and better information about requirements to access commercial markets.

Researchers interviewed 42 marketers and 64 growers from throughout the state to determine their role in and opinions of the fruit and vegetable system. A major goal was to determine and evaluate differences and compatibilities between produce growers and marketers in Alabama.



About three-fourths of the fresh-produce purchasing firms contacted were retailers, while the balance was equally represented by wholesalers and brokers. About two-thirds of these firms were sole proprietorships, while 21% and 14% were corporations and partnerships, respectively. Most of these firms (92%) handled locally grown produce, and they indicated general satisfaction with the experience. Brokers tended to handle cabbage, potatoes, tomatoes, and watermelons most frequently. Tomatoes, apples, peaches, potatoes, sweet corn, and watermelons were most important to retailers. Retailers want fresh, clean, appropriately packaged, and vine-ripe products from local growers. Although retailers stated a desire to sell more locally grown products, they indicated that some local producers would have difficulty meeting fairly rigid market requirements and conditions. Several considerations that influence the marketers' willingness and ability to purchase locally grown crops were identified. Top-quality produce was the strongest factor. Of secondary importance was access to an adequate volume of products. Retailers stated that producers generally could not provide a dependable level of supply for a sustained period; one or two deliveries were

Produce, continued on page 10

generally not adequate to establish an account with a grower. Another consideration was the retailers' hesitation to interrupt or decrease the flow of product from normal channels. Loss of "good will" with present suppliers could adversely affect future product flows to the firm. Even with these recognized difficulties, retailers believed that local producers could favorably market their products through retail outlets or their assembly/distribution facilities in the future.

Produce growers had averages of 31 years experience as farmers and 27 years as fruit and vegetable growers. Farm size ranged from three to 1,900 acres, with an average of 135 acres. Fruit acreage ranged from one to 180 acres, with an average of 49 acres. Vegetable acreage ranged one to 600 acres, with an average of 71 acres. Those growers producing strawberries and tomatoes on plastic averaged 6.1 and 5.1 acres, respectively. Half of the 64 farmers had some form of irrigation.

About two-thirds of the producers reported a strong preference for direct markets: 57% sold through farmers markets, and 31% used roadside stands or pick-your-own operations. Four percent used brokers, while

3% sold through wholesalers/retailers. More than half the identified buyers (53%) were located in the Birmingham market; Montgomery and Dothan markets were each the cited destinations for 6% of the growers. Average distance traveled to market was 73 miles.

The primary reason growers chose a particular outlet was convenience (53%). Other reasons noted for selecting a particular market were: only market available (18%), owner of retail outlet (7%), large volume required to use the market (6%), repeat sales (5%), and better prices (3%). The top-two problems associated with markets used were insufficient buyers and low price. Fifty-four percent of producers stated that the price paid for their produce was unsatisfactory. Weather (34%), low selling price (26%), and availability of capital (13%) were primary factors identified by growers as limiting their production.

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Fifty-four percent of producers stated that the price paid for their produce was unsatisfactory.

When questioned about the availability of on-farm facilities, all producers indicated capability for grading; 86% had storage facilities; 84% had packing facilities; and 30% had cooling facilities. Growers were questioned about the future of their operations. Twenty percent felt very good about the future, while 68% expected a good future, and 6% were not optimistic. Two percent said they plan to quit farming. Others felt there was insufficient reward for their effort but planned to continue farming because that was their only skill.

In conclusion, firms are interested in handling locally grown produce, but they want it on a basis consistent with normal market standards. Basically, retailers or their assembly/distribution units can operate without local produce. But under appropriate conditions, their business could be enhanced by availability of good-quality local crops. In fact, some retailers explicitly promote locally grown items. Retailers desire stability in product flow or, at least, sufficient lead time to promote items that are readily available.

Alabama produce growers are primarily oriented toward direct markets, which seem to become saturated with products during the primary production season, resulting in low prices and unsold products. Nevertheless, several viable direct markets exist in Alabama. And some producers are effectively accessing commercial outlets with such items as watermelons, bell pepper, green beans, tomatoes, greens, and apples. Unfortunately, many others lack sufficient volume of quality produce to access commercial outlets. Also, producers often

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Retailers want fresh, clean, appropriately packaged, and vine-ripe products from local growers.

have facilities insufficient to maintain produce quality or package it appropriately. Post-harvest produce handling is often as important as production methods in determining the quality of a product and shelf life.

Future growth of the fruit and vegetable industry will depend on better coordination between growers and marketers. Coordination can be improved through contracting, cooperative organizations, and leadership by key individuals throughout the state. Presently, much produce is planted and grown without detailed early consideration of potential markets. Improved coordination would facilitate interaction among participants and the orderly flow of products on a timely basis.

Alabama growers need to understand that the commercial produce system can exist without them. However, growers will have difficulty moving volume without the commercial outlets. If growers can help brokers, wholesalers, and retailers be profitable, they will enhance their chances for success in the commercial sector.

Adrian is a Professor, Kiser is a Research Assistant, and Frazier is a former Graduate Research Assistant in Agricultural Economics and Rural Sociology.

Sustaining History

AUBURN'S OLD ROTATION PROVIDING A CENTURY OF INFORMATION

Charles C. Mitchell, Jr.

ONE HUNDRED YEARS AGO Professor John F. Duggar at the Alabama Polytechnic Institute established a 13-plot experiment to test his theories about sustainable cotton production for Alabama. A century later, that experiment continues to provide valuable information using lessons from the past to ensure the future of Alabama agriculture.

The Old Rotation (c. 1896) is located on the Auburn University campus and is the oldest, continuous cotton experiment in the world and the third oldest field crop experiment in the United States on its original site. It was placed on the National Register of Historical Places in 1988.

Duggar was concerned about preserving Alabama's soils and sustaining crop production. In 1896, more than 3.5 million acres of cotton were planted in Alabama, but the average yield was only 130 pounds of lint per acre. Alabama cotton farmers planted their crop year after year on the same land. New land for clearing and cropping had almost been exhausted. Very few amendments were applied to the soil and use of crop rotations and winter cover crops was uncommon. Excessive soil erosion, declining yields, and low farm income were common.

At the time, Alabama's economy and the welfare of its citizens depended upon sustainable cotton production. Some researchers suggested substituting tobacco culture for cotton. However, Duggar undoubtedly believed that Alabama soils could sustain profitable yields of cotton if a crop rotation system that included winter legumes could be developed.

Old Rotation, continued on page 12

Corn, oat, and cowpea were familiar crops on 19th century Alabama cotton farms. These grains and their fodder fed the draft animals that worked the fields. Corn also was a staple in the diet of the people who lived on the land. Almost as many acres of corn as cotton were planted to support the cotton cash crop, and corn was usually planted on the more productive bottomlands. Cowpea was one of the few summer annual legumes that grew well in the South. Therefore, corn, oat, and cowpea were logical crops to include in a crop rotation system.

"[Based on data from the Old Rotation it appears]... cotton as a crop does not deplete the soil or run it down excessively. The cultural practices of leaving the land bare through the winter and of not preventing erosion are responsible for the generally low fertility level of many soils on which cotton is grown."

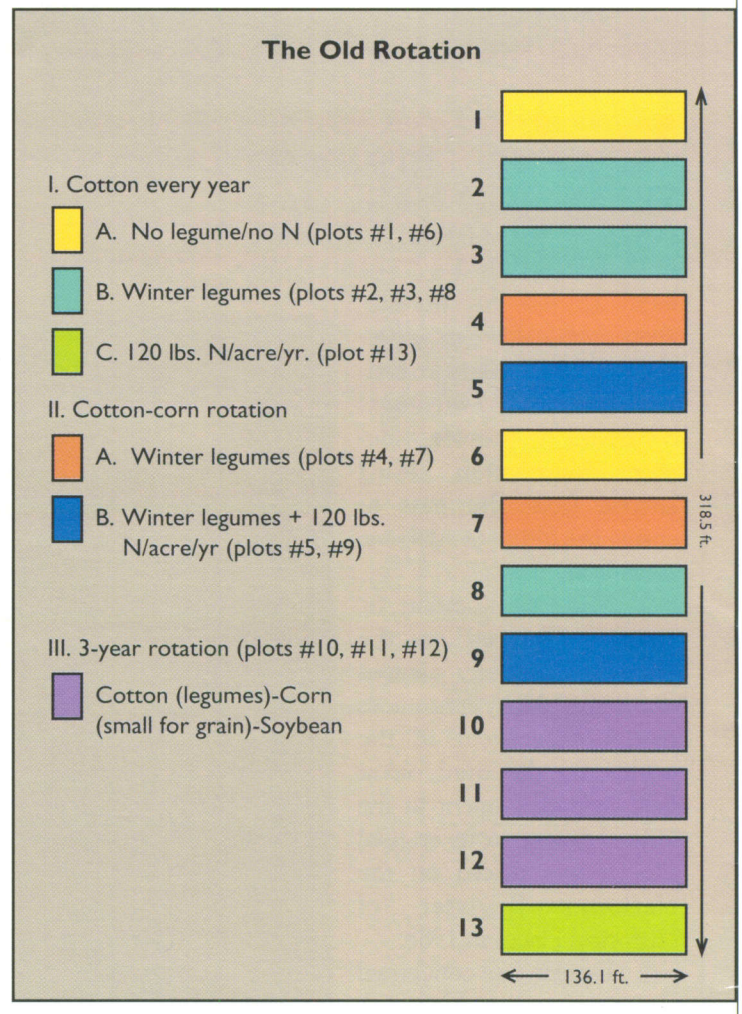
F.L. DAVIS (1942)

Though no statement of the Old Rotation's original objectives can be found in historical records, the treatments themselves suggest that the objectives of the experiment were to (1) determine the effect of rotating cotton with other crops to improve yields and (2) determine the effect of winter legume (crimson clover and/or vetch) in cotton production systems.

These same objectives are used today. However, today the Old Rotation provides a site for researchers, students, and campus visitors to study first hand 100 years of sustainable agricultural research.

Duggar went on to serve as the third AAES director from 1903 to 1921. During this time, he continued to oversee the management of the Old Rotation. When the Department of Agronomy and Soils was established in 1919, management of the experiment became the department's responsibility. The area around the Old Rotation became known as the "Agronomy Farm." In 1977, most field crop research was moved from the AU campus to the new farm at E.V. Smith Research Center near Shorter. However, the Old Rotation re-mained on campus and, today, the Department of Agronomy and Soils works with the AAES to maintain the site.

Though the original records of the Old Rotation from 1896 to 1919 were destroyed in a fire that razed Comer Agricultural Hall in 1920, some hand-written records were later found. Other gaps exist in the records. However, publications, research papers and abstracts, popular articles, and crop recommendations have developed from information gathered from plots in the Old Rotation. All these sources help document the experiment's history and have added to the base of knowledge it has provided to Alabama agriculture.



Schematic of Old Rotation layout and cropping systems used since 1956.

The Old Rotation site straddles the juncture of the southern Piedmont Plateau and the Gulf Coastal Plain physiographic regions in East-Central Alabama. The Old Rotation consists of 13 plots on one acre of a Pacolet fine sandy loam. Today, the rotation treatments are often summarized as shown in the figure.

All plots have received the same annual rate of phosphorus (P) and potassium (K). However, the actual rate applied has gradually increased over the years from a total annual application of 0-22-19 pounds $N\text{-}P_2O_5\text{-}K_2O$ per acre per year in 1896 to 0-80-60 since 1956. Ground, dolomitic agricultural limestone is applied as needed to maintain the soil pH above 5.8.

Many of the crop growth problems during the first 50 years resulted from inadequate applications of K fertilizers and removal of cowpea hay. Phosphorus deficiencies in winter

legumes often led to low dry matter production and low cotton yields as a result of low N in the soil from the legume. This observation led to split P and K fertilizer applications, which continue today in some plots. However, since soil P has accumulated to high levels and soil K is in the medium range, deficiencies are no longer observed and there are no cotton yield differences due to split P and K applications.

When the Old Rotation was established 100 years ago, it was intended to address immediate production problems in agriculture. Duggar's initial goals were realized early in the history of the Old Rotation. It is, however, a vision that has been far-reaching and, luckily, has been carried on by Duggar's successors.

> *"The South will come into its own when its fields are green in winter."*
> HENRY GRADY

Today, the Old Rotation continues to provide new information for Alabama agriculture, but its monumental value lies in its rich historical base of information. Modern concerns about sustainable agricultural production may not have been on the mind of Duggar and his successors, but the Old Rotation's unique blending of the past and the future make it a remarkable and invaluable acre of land. It is a true testament to the value of history and farsightedness.

Mitchell is a Professor of Agronomy and Soils.

The Past Is Still Present:

Applying Old Rotations' Historical Data to Modern Production Issues

Charles C. Mitchell, Jr., Francisco J. Arriaga, D. Wayne Reeves, and James A. Entry

Data collected for 100 years from Auburn University's Old Rotation provide today's scientists and farmers with valuable information about the effectiveness of management strategies and also ideas about how to sustain agriculture for another century.

Yield Trends

Some of that helpful information can be found by tracking yield trends from the Old Rotation. For example, seed cotton yield records from plot 3 (cotton every year with only legume N) illustrate the wide yield variability expected under nonirrigated conditions as used in the Old Rotation and practiced by most Alabama growers (see figure). An interesting observation is that rarely are two consecutive years with very high yields observed in the Old Rotation. Likewise, two consecutive low-yielding years are also rare.

In addition to tracking production trends, yield data also have helped identify problems and offer solutions in cotton production. Five-year running average yields seemed to decline slightly during the first 25 years of the Old Rotation. No doubt some of this decline was due to the boll weevil, which entered Alabama in 1911 and became widespread by 1914. Some of this decline also was attributed to deficiencies in phosphorous (P) and potassium (K), and resulted in revisions of P and K rate recommendations for Alabama soils.

Winter Legumes and Nitrogen

Nitrogen (N) fertilization trends also can be traced through Old Rotation data. With no N fertilization and no winter legumes to supply N (plot 6), cotton yield potential gradually declined over a period of 15 to 20 years and then stabilized at about half of the beginning yields (Table 1). This is a reflection of the gradual breakdown of soil organic matter.

Old Rotation, continued on page 14

Including a winter legume (crimson clover and/or vetch) as the only source of N for the cotton crop (plots 3 and 8 in table) has consistently produced average yields higher than those produced from applying 120 pounds N per acre to a cotton monoculture (plot 13 in Table 1). The N-fertilized plot (plot 13) was added in 1956. Professor J.F. Duggar, founder of the Old Rotation, effectively demonstrated that winter legumes could improve yields of continuous cotton during the first few years of the Old Rotation. These data show that this trend has continued for 100 years.

Recent measurements on winter legumes indicate that between 80 and 150 pounds N per acre is fixed in the above-ground portion of the legume depending upon the legume growth. If most of this N is available to cotton, it will be adequate for nonirrigated cotton.

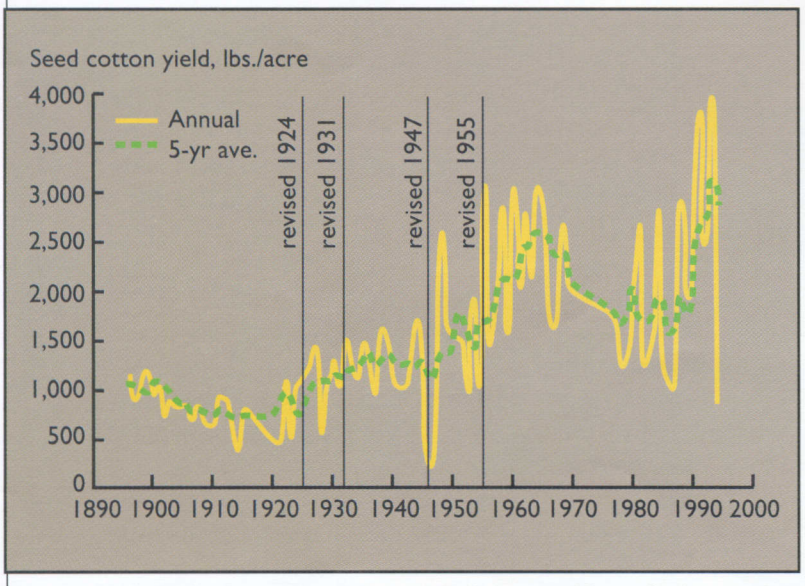
A nitrogen budget for the treatments in the Old Rotation (using yield, fertilization, and crop removal estimates during the past decade) suggest that N use efficiency is the same for continuous cotton regardless of the source of N. Nitrogen use efficiency appears higher for the three-year rotation because of the high N removal associated with soybean and because only 60 pounds of fertilizer N per acre was applied during the three-year period.

Cotton Rotations

Data also show that there is a definite yield advantage to rotating cotton with other crops (Table 1). However, the two-year cotton-winter legume-corn rotation is as beneficial to cotton yields as the three-year rotation. Low yields for nonirrigated corn in Central Alabama have made a cotton-corn rotation less attractive to growers than continuous cotton.[1]

In the three-year rotation, soybeans have averaged 35 bushels per acre per year since 1956. Small grain (wheat or rye) harvested for grain prior to planting soybeans has averaged 27 bushels per acre for rye and 43 bushels per acre for wheat since 1975.

[1]An economic analysis of the cropping systems in the Old Rotation can be found in *Highlights* (1989) vol. 36(4), "Old Rotation Results Identify Least Risky Rotation"



Annual and five-year running average seed cotton yields on plot 3 (annual cotton with winter legume N) on the Old Rotation, 1896-1995.

Soil Quality

Soil quality issues also have been addressed through the Old Rotation. Almost all definitions of "soil quality" include some aspect of enhancing productivity of the land while protecting the environment. Many factors affect soil quality and only recently have soil quality measurements been taken on soils from the Old Rotation. Although there are no records of the condition of this soil in 1896, researchers can compare present day differences among cropping systems (treatments).

> *"It is in fact impossible for any culture to be sound and healthy without a proper respect and proper regard for the soil, no matter how many urban dwellers think that their victuals come from groceries and delicatessens and their milk from cans."*
>
> ANDREW LYTHE

Measurements related to soil quality include soil texture, bulk density, infiltration rate, water holding capacity, soil organic matter, and mineral nutrients (soil tests results).

Old Rotation data show that productivity has increased in all treatments.[2] Treatment differences in soil tilth also have been observed by individuals plowing, planting, and cultivating the Old Rotation. Soil on plot 13, which has been planted to cotton every year since 1956 with only commercial N fertilization, has a history of severe crusting after planting. Poor cotton stands frequently result when rains cause crusting prior to seedling emergence. The problem has also been observed on other plots planted to cotton every year with no winter legume (plots 1 and 6). Some

[2]See Highlights , Winter, 1994, "Old Rotation Documents Sustainable Cotton Production."

soil physical measurements suggest that the observed soil quality problems are due to long-term treatment effects.

In general, treatments with observed crusting problems (plots 1,6, and 13) had lower soil organic matter (SOM), higher cone penetrometer resistance, higher bulk density, fewer water stable aggregates, and lower hydraulic conductivity (Table 2). This confirms poor soil structure and soil compaction in these treatments compared to those treatments that use winter legumes and crop rotations.

Soil Organic Matter

Soil organic matter is an important indicator of soil quality because it influences soil structure, which affects soil stability and its capacity to provide water, and it is the controlling factor in nutrient cycling.

No records were kept of SOM measurements on the Old Rotation before 1988. Measurements in the plow layer were made in 1988, 1992, and in 1994 (Table 2). Results of this investigation show that long-term planting of winter legumes and crop rotations significantly increase SOM.

The plots with the highest SOM are also the highest yielding plots. Increased SOM can be viewed as a consequence of improved production. However, the relationship between SOM and yield suggests that SOM may also be viewed as a predictor of relative crop yield. There is a significant trend toward higher cotton yields in plots with higher SOM.

These results show that cover crops grown on cropland in the southeastern United States are beneficial as they maintain SOM, improve soil physical and chemical characteristics, supply the soil with additional N and reduce erosion of topsoil during the high rainfall winter months — all factors relating to soil quality.

These results also show the value of long-term research for agriculture. After 100 years, the Old Rotation continues to provide valuable information for a sustainable Alabama agriculture.

Table 1. Ten-year Average Seed Cotton and Corn Grain Yields, 1896-1995

Treatment (plots)	1896-1905	1906-1915	1916-1925	1926-1935	1936-1945	1946-1955	1956-1965	1966-1975	1976-1985	1986-1995
					Seed cotton yields (lb./a.)					
I. Continuous cotton										
A. No N/no leg. (#6)	800	630	340	510	370	510	620	710	610	930
B+ legumes (#3,#8)	860	680	640	160	1,230	1,580	2,360	2,100	1,840	2,230
C. 120 lb. N/acre (#13)	——	——	——	——	——	——	1,960	2,040	1,630	1,860
II. Cotton-corn rotation										
A. +legumes (#4,#7)	870	750	770	1,260	1,440	1,950	2,640	2,410	1,850	2,290
B. +leg./+N (#5,#9)[1]	890	950	1,150	1,190	1,170	1,680	2,500	2,030	2,170	2,560
III. Three-yr. rotation (#10,#11,#12)	740	804	704	1,150	1,140	1,690	2,640	2,390	2,210	2,240
					Corn grain yields (bu./a.)[2]					
I. Continuous corn										
A. No N/no leg (#2)	18	11	9	10	——	——	——	——	——	——
B. +legumes (#1)	19	16	18	26	——	——	——	——	——	——
II. Cotton-corn rotation										
A. +legumes (#4,#7)	18	13	15	29	34	40	69	39	33	73
B. +leg/+N (#5,#9)[1]	——	——	——	——	——	——	——	[3]	42	96
III. Three-yr. rotation (#10,#11,#12)	16	13	15	29	36	47	86	68	33	107

[1]120 pounds N per acre added as ammonium nitrate since 1956 to cotton and corn. Prior to this, a summer legume (cowpea) was planted in rotation with cotton and winter legumes.
[2]Corn grain yields are calculated using 56 pounds per bushel at 15.5% moisture.
[3]Insufficient data.

Table 2. Long-term Treatment Effects in the Old Rotation on Selected Soil Physical Measurements

Treatment	Plots	Cation exchange capacity	Plow-layer N	Organic matter	Bulk density 0-30cm	Cone penetrometer resistance to 30 cm	Water stable aggregates	Hydraulic conductivity (K-sat)
		meq/100g	*pct.*	*pct.*	*g/cm^3*	*bars*	*pct.*	*x 10^{-3} cm s^{-1}*
I. Continuous cotton								
A. No legumes	1,6	3.9	0.11	0.8	1.84	29	24	1.37
B. +legumes	2,3,8	4.7	0.14	1.8	1.85	28	38	1.39
C. 120 lb. N/acre	13	5.4	0.10	1.6	1.73	20	22	2.89
II. Two-yr. rotation								
A. +legumes	4,7	4.4	0.13	1.8	1.75	19	40	2.56
B. +leg./+120 lb. N/acre	5,9	5.1	0.11	2.1	1.66	20	38	2.84
III. Three-yr. rotation	10,11,12	4.9	0.14	2.3	1.56	19	39	3.66

Mitchell is a Professor and Arriaga is a Research Associate, Reeves is an Adjunct Professor and USDA Research Scientist, and Entry is an Assistant Professor of Agronomy and Soils.

Organic Insecticides Not as Effective as Synthetics, But Still Useful for Vegetable Insect Control

Teri H. Briggs, Geoff W. Zehnder , and James B. Witt

This cabbage with noticeable worm-feeding damage on its outer leaves is not necessarily unmarketable. It is the head that is considered when assigning damage ratings. In this case, the cabbage was given a rating of 3, which means it has moderate wrapper leaf damage.

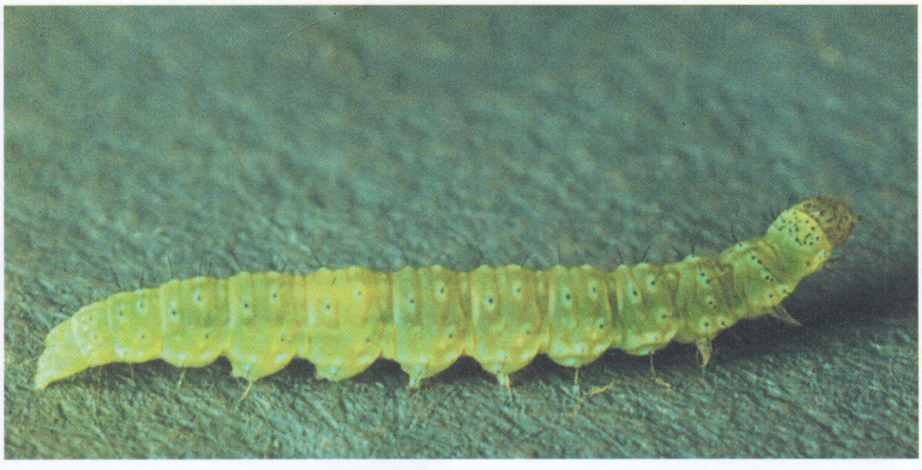
VARIOUS MOTH LARVAE CAN CAUSE SERIOUS DAMAGE to cabbage grown in the South, but concerns over synthetic pesticide residues in food and the environment prompt commercial vegetable growers and home gardeners to seek natural pest control alternatives. Organic gardening literature is rich with anecdotal evidence for the effectiveness of organic insecticides. However, few formal studies have been done to evaluate these materials.

An AAES experiment compared a standard synthetic pyrethroid insecticide with some commonly available organic insecticides for control of diamondback moth and cabbage looper larvae, or worms, on cabbage. Results indicate that the organic insecticides, which are composed of natural, non-polluting materials, do not provide the same high level of worm control as pyrethroids. But they do demonstrate moderate to good activity against the worms and can acceptably control worm feeding damage.

Adult female diamondback and cabbage looper moths lay eggs on cabbage plants. The hatching worms feed on the outer leaves and heads, causing defoliation and reduction in grade or marketability of cabbage.

Fortuna cabbage was transplanted on March 18 at the E.V. Smith Research Center in Shorter. Treatment rows were sprayed on a weekly schedule until harvest using a backpack sprayer with three hollow-cone nozzles per row. Ivory Snow liquid laundry soap (at a rate of 0.5 milliliter [ml], or six drops per two-liter bottle) was added to the spray mixture in all spray treatments to enhance even wetting of the cabbage leaves and avoid large drops of spray on the leaves. Spray volume was 55 gallons

Obvious signs of cabbage looper feeding include feeding damage, the physical appearance of the larva, and the presence of larva frass.



The larva is the stage of the diamondback moth that causes feeding damage.

per acre at a pressure of 40 pounds per square inch. Worm counts were recorded weekly, and a visual damage rating was assigned at harvest on June 13. The table lists the seven materials evaluated in the study.

Karate, applied at a rate of 0.75 ml per two-liter bottle, was used as the standard synthetic pyrethroid insecticide. (Note: a gallon is 3.8 liters, and an ounce is 59 ml.) Commonly used by commercial growers to control moth larvae, this product contains 13.1% lambda-cyhalothrin, the active ingredient.

Garlic Barrier, a 100% garlic-juice product advertised as an insect repellent, was obtained from GRAB-IT Enterprises in Jackson, Ala. This product enters the plants through stomata (breathing pores in the leaves) and moves systemically throughout the plant. As recommended by the manufacturer, Garlic Barrier was mixed with an equal amount of fish oil (exact composition unknown). Garlic barrier and fish oil were each applied at the rate of 200 ml per two-liter bottle.

The primary ingredient (83.2%) in Organic Plus, obtained from Organic Plus, Inc., of San Antonio, is diatomaceous earth, or finely ground fossilized shells of tiny aquatic organisms called diatoms. These microscopic pieces of silica can pierce the worm cuticle on contact, resulting in loss of body fluids and ultimate death. Organic Plus also contains 0.2% pyrethrins, a natural insecticide from chrysanthemum plants, and 1.1% piperonyl butoxide, a compound added to block insect resistance to the pyrethrin. Organic Plus was applied at 30 grams per two-liter bottle. (Note: one ounce is 28 grams.)

Align, manufactured by Agri-Dyne Technologies of Salt Lake City, Utah, is a botanical insecticide containing 3% azadirachtin, a natural

Organic Insecticides, continued on page 18

Effectiveness of Organic Insecticides Against Diamondback Moth and Cabbage Looper Larvae in Cabbage

Treatment[1]	Avg. no. larvae/plant								Damage rating[2]
	May 21		May 30		June 4		Season avg.		
	DBM[3]	CL[4]	DBM	CL	DBM	CL	DBM	CL	
Karate	0.1	0.1	0.2	0.1	0.1	0.1	0.4	0.1	1.60
Garlic Barrier & Fish Oil	0.6	0.2	1.1	0.3	0.1	0.8	0.6	0.3	2.95
Organic Plus	0.5	0.0	0.9	0.2	0.0	1.0	0.7	0.3	3.14
Align	0.7	0.0	0.6	0.1	0.0	0.3	0.8	0.1	2.15
Javelin WG	0.6	0.1	0.7	0.3	0.5	0.2	0.9	0.2	2.15
McCormick Ground Red Pepper	1.8	0.2	2.1	0.4	0.2	1.6	1.0	0.5	3.87
Ivory Snow Laundry Soap	1.7	0.2	1.6	0.2	0.1	0.5	1.1	0.2	3.10
Control	4.2	0.7	4.9	0.4	0.8	2.4	2.2	0.7	4.70

[1]Rates of application are described in the text. All treatments, including the control, contained six drops (0.5 ml) of Ivory Snow per two-liter bottle to wet the leaves more evenly. The Ivory Snow treatment contained a total of 20 ml of soap.
[2]Damage rating: 1 = no apparent insect feeding; 2 = minor feeding on wrapper leaves; 3 = moderate feeding on wrapper leaves with no head damage; 4 = moderate feeding on wrapper leaves with minor feeding on head. A rating of 4 and above is considered unmarketable because even slight damage is not acceptable.
[3]DBM = diamondback moth larvae.
[4] CL = cabbage looper moth larvae.

insecticide obtained from the tropical neem tree. Azadirachtin has activity against a wide variety of insect species, including moth larvae, but has no reported adverse effects on mammals. Align was applied at 4.4 ml per two-liter bottle.

The active ingredient in Javelin WG, manufactured by Sandoz Crop Protection of Des Plaines, Ill., is a toxin obtained from a bacterium, Bacillus thuringiensis variety kurstaki. The toxin is active only against moth larvae; it acts as a stomach poison that must be consumed by the worms for activity to occur. Javelin WG was applied at the rate of 3.8 grams per two-liter bottle.

Ground red pepper, obtained at a local super market, has also been reported as an insect repellent. The spice was applied at the rate of one tablespoon per two-liter bottle.

The Ivory Snow liquid laundry detergent used in this test was obtained from a local supermarket and applied at the rate of 20 ml per two-liter bottle. The 0.5 ml of Ivory that all other treatments contained does not affect the insects, but the 20 ml concentration is harmful to them. Insecticidal soaps act on contact against soft-bodied insects by degrading the insect cuticle. They also may suffocate the insect by blocking spiracle openings.

Diamondback moth numbers reached nearly five per plant on May 30, and peak cabbage looper numbers (2.4 per plant) were recorded on June 4. Numbers of diamondback moth larvae were highest in the nontreated control on May 21 and 30. Diamondback larvae counts were significantly lower in all treatments, compared with the control, on these dates.

The season average diamondback counts indicated that Karate provided the best control. The organic products Garlic Barrier and Organic Plus provided the next highest level of protection. Align and Javelin WG were slightly less effective than these products in reducing diamondback numbers. Red pepper and Ivory soap had the least effect on the diamondback population but were still more active than the control. All treatments, except red pepper, provided a significant level of cabbage looper control on June 4, when worm numbers were at their highest.

Damage ratings reflected the degree of worm control resulting from the treatments. Cabbage plants in the Karate treatment exhibited the least worm damage, while plants in the red pepper treatment exhibited the most. However, the average worm damage ratings in all of the organic treatments were below 4, indicating that most of the damage occurred on the outer leaves, and was not sufficient to render the plant unmarketable. Of the organic materials, Javelin WG and Align were best at controlling worm damage, followed closely by Garlic Barrier. While red pepper was one of the least effective treatments, it did provide a surprising level of control. Sprays were applied at seven-day intervals, and the red pepper was not expected to have long residual activity, but it still offered moderate control of worms and damage.

Of all the treatments, the synthetic pesticide Karate gave the best control of cabbage worms. However, the organic materials are useful for home gardeners and commercial producers who want to avoid synthetic chemical residues and can accept some insect damage on their cabbages.

Briggs is a Research Technician, and Zehnder is an Associate Professor in the Department of Entomology. Witt is Superintendent of the E.V. Smith Research Center Horticulture Unit.

Feather Meal Does Not Reduce Carcass Quality of Finisher Pigs

Lee I. Chiba, Henry W. Ivey, Keith A. Cummins, and Brian E. Gamble

As the world's population grows, sources of protein for human nutrition become more and more valuable. High-quality protein products are essential in human diets, but they also are a vital component of diets fed to pigs in the swine industry. Finding viable alternative protein sources for pigs is necessary to avoid conflicts between human food requirements and the swine industry. AAES research indicates that hydrolyzed feather meal may be a suitable alternative protein source for finisher pigs.

Feather meal, a major byproduct of poultry processing, is high in protein (80-85%) but deficient in some amino acids, especially lysine. Because adequate lysine is the primary concern for most swine diets, it is generally recommended that feather meal be limited to about 5% of the diet for optimum performance. Previous AAES research demonstrated that feather meal is an effective source of extra dietary nitrogen to enhance leanness of finisher pigs. Results from that study also suggested that pigs may be able to utilize more than 5% feather meal in their diets. However, in that study, corn and soybean meal provided a fixed amount of protein and lysine, and feather meal provided additional protein and lysine. A recent study was conducted to evaluate the value of feather meal as a source of protein supplement and to determine whether soybean meal can be completely replaced by a combination of feather meal and crystalline lysine.To determine the optimum concentration of dietary feather meal, five corn-soybean meal diets were formulated to contain 0.73% lysine and 0-12% feather meal (see table). This lysine concentration is 20.8% greater than the current National Research Council (NRC) recommendation. Two additional diets containing 9% feather meal were used to test the possibility of completely replacing soybean meal with feather meal. Both of these corn-feather meal diets were formulated to have the same protein content as the corn-soybean meal diet with 0% feather meal. Crystalline lysine was added to one of the corn-feather meal diets to achieve 0.73% lysine.

At an average weight of 150 pounds, pigs housed in individual pens were assigned to one of these seven diets. To assess carcass traits, all pigs were slaughtered when they weighed approximately 220 pounds. Results are summarized in the table.

Weight gain and gain-to-feed ratio (a measure of feed efficiency) decreased linearly as the dietary feather

Feather Meal, continued on page 20

meal content increased. However, greater weight gain of pigs fed the diet containing 3% feather meal and greater feed intake of pigs fed the diet containing 12% feather meal seemed to be primarily responsible for the overall linear decreases. These reductions were not consistent or progressive as dietary feather meal increased from 0% to 12%. The rate and efficiency of weight gain in pigs fed other soybean meal diets were relatively similar.

Carcass quality of finisher pigs was not greatly affected by the inclusion of up to 9% feather meal. However, the diet with 12% feather meal did decrease carcass quality. This is illustrated by reductions in proportion of carcass lean (48.7% vs. 51.6%) and the rate of lean growth (0.52 vs. 0.66 pounds per day), compared with pigs fed other combinations of soybean meal and feather meal.

Because of its lysine deficiency, it is recommended that feather meal should be incorporated into swine diets based on the lysine content. However, this method would increase both the amount of feather meal needed to satisfy the pig's lysine requirement and the protein content of diets. Supplementation of feather meal diets with the most deficient amino acid, lysine, is likely to decrease not only the amount of dietary feather meal required, but also the protein content of swine diets. Thus, lysine supplementation of feather meal diets could alleviate the environmental concern resulting from the increased nitrogen excretion in the urine of pigs fed high-protein diets.

As expected, pigs fed the corn-feather meal diet without lysine supplementation grew more slowly and less efficiently than those fed the soybean meal diets containing 0% or 9% feather meal. The addition of crystalline lysine to bring the lysine concentration up to 0.73% did not alleviate growth depression caused by completely replacing soybean meal with 9% feather meal.

Effects of Dietary Hydrolyzed Feather Meal on Growth Performance and Carcass Traits of Finisher Pigs

	SBM diets containing FM (%)[1]					FM diets[2]	
	0	3	6	9	12	Iso-N	+Lys
Composition of diets							
Protein (pct.)	15.0	16.6	18.3	20.0	21.6	15.0	15.0
Lysine (pct.)	0.73	0.73	0.73	0.73	0.73	0.37	0.73
Growth performance							
Weight gain (lb./day)	2.05	2.19	1.91	1.89	1.90	1.67	1.68
Gain:feed ratio (lb./lb.)	0.28	0.29	0.27	0.28	0.24	0.24	0.25
Carcass traits							
10th rib backfat (in.)	1.08	1.02	0.93	0.91	1.09	1.26	0.98
Loin muscle area (sq. in.)	5.52	6.06	5.78	5.66	5.50	4.74	5.58
Lean containing 5% fat							
Proportion (pct.)	51.2	50.9	53.1	51.2	48.7	45.2	50.7
Accretion (lb./day)	0.67	0.66	0.71	0.62	0.52	0.29	0.49

[1]SBM = soybean meal; FM = hydrolyzed feather meal. FM contributed 0% of the total lysine in the 0% FM diet; 6.9% in the 3% FM diet; 13.8% in the 6% FM diet; 20.7% in the 9% FM diet; and 27.6% in the 12% FM diet. A dried fat product was used to achieve a similar energy content in these five diets, as well as the two corn-feather meal diets.

[2]Lys = lysine. These two diets, containing 9% FM and no SBM, were formulated to be the same protein content as SBM containing 0% FM (Iso-N). L-lysine˜HCl was added to one of the Iso-N diets to achieve 0.73% lysine (+Lys).

This lack of growth response to lysine supplementation is difficult to explain. The amino acid content of this diet was at least 20.8% greater than NRC recommendations. For instance, the second most deficient amino acid, tryptophan, was 25.3% greater than the NRC requirement. Total content of all amino acids, therefore, should have been adequate. One possible explanation is that pigs may utilize not only lysine but other amino acids in feather meal less efficiently than those in soybean meal. This contention, however, does not explain the carcass data.

Carcass backfat, loin muscle area, and proportion of lean improved greatly with lysine supplementation

Carcass quality was generally lower in pigs fed the two corn-feather meal diets than those fed the corn-soybean meal diets containing 0% or 9% feather meal. However, carcass backfat, loin muscle area, and proportion of lean improved greatly with lysine supplementation, and these traits were very similar to pigs fed the soybean meal diet containing 0% or 9% feather meal.

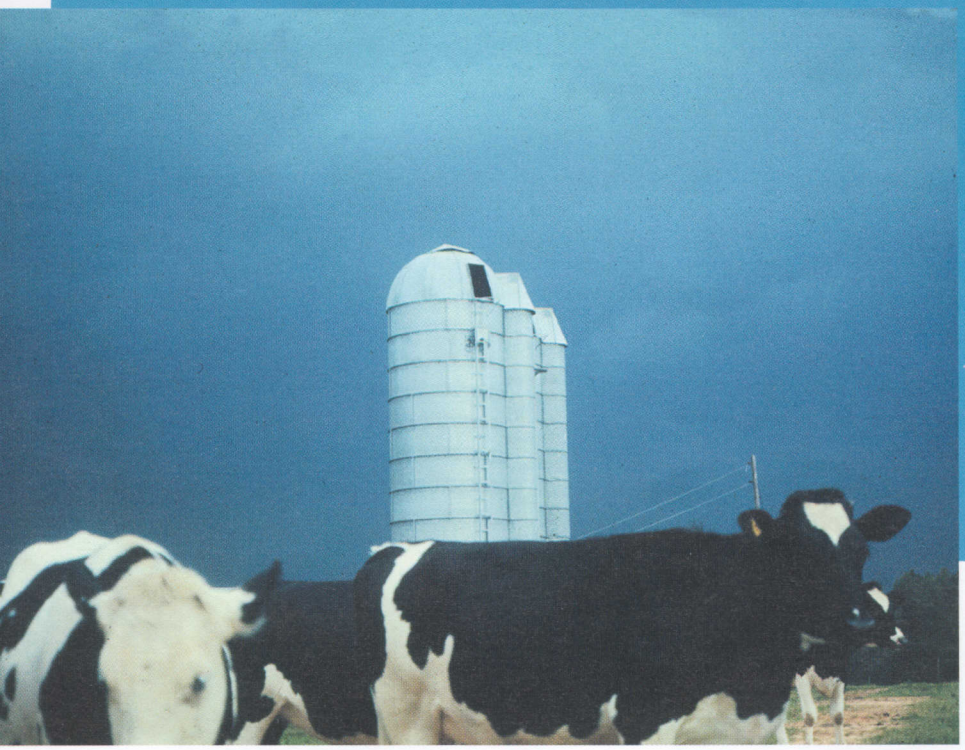
Although lean growth rate was lower in pigs fed the lysine-supplemented feather meal diet than those fed the corn-soybean meal diet containing 0% or 9% feather meal, this decrease was caused by an extension in the feeding period (about seven days).

In conclusion, these results indicate that up to 9% feather meal can be incorporated in the finisher pig diet with no adverse effects on carcass traits and little effect on growth rate and efficiency. In addition, although weight gain may be reduced, feather meal can be used as the only source of protein supplementation without decreasing carcass quality, provided that the diet is supplemented with crystalline lysine. It is not known whether the growth depression caused by a complete replacement of soybean meal with feather meal can be alleviated by supplementation with other amino acids, thus avoiding the increase in feeding period. Further research is needed to explore the full potential of utilizing feather meal in swine diets. Nevertheless, considering the market incentives for leaner pigs and possible reduction of feed costs, feather meal may be a suitable alternative protein supplement for finisher pigs.

Chiba is an Associate Professor and Cummins is a Professor of Animal and Dairy Sciences. Ivey is Superintendent (retired), and Gamble is an Assistant Superintendent of the Wiregrass Substation in Headland.

Shaochen C. Gu, B.R. "Pete" Moss, and John C. Lin

Cottonseed Hulls as a Feed Source for Dairy Cattle



CORN SILAGE is an excellent forage source, but silages are often inadequate for Alabama dairy farms. Therefore, dairy producers must find alternative forage sources that are economical, easy to mix in total rations, and support satisfactory milk production. AAES research indicates that cottonseed hulls may provide an economical and effective alternative for dairy producers.

Typical forage sources used by dairy producers include alfalfa and grass hat The availability of alfalfa hay, however, is limited, expensive to import, and it must be chopped if used in total mixed rations (TMR). Grass hay quality often is low, the supply may be limited, and it also must be chopped if used in TMR. Cottonseed hulls, byproducts of the region's thriving cotton industry, are often an economical source of roughage and mix well in TMR.

Protein sources also are of interest because milk yield may increase if cows are fed certain feed combinations. Best results are often obtained with protein sources that are partially digested in the rumen with the remainder undigested in the rumen (UIP) but digested in the lower gastrointestinal tract. To get such digestion, a mixture of protein sources such as soybean meal and various byproduct protein supplements are considered advantageous. However, forage sources may affect the protein digested in the rumen, and therefore affects the value of protein sources.

To learn more about the value of cottonseed hulls in dairy cattle diets and their effects on protein sources, two studies were conducted at the E.V. Smith Research Center Dairy Unit in Shorter. In the first study, 72 early-lactation Holstein cows were fed diets (1) corn silage as the only forage, or diets in which (2) cottonseed hulls, (3) coastal bermudagrass hay , or (4) alfalfa hay replaced 10% of the corn silage on the dry matter (DM) basis. All diets were equal in crude protein (16.5%), net energy for lactation (NEL, 0.74 Mcal per pound), and mineral contents.

For each forage source, nine cows were fed either soybean meal as

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a low UIP supplement or a soybean, feather, and blood meal combination as a high UIP supplement. Milk, milk composition, feed intake, body weights, and metabolic compound data were collected for 10 weeks.

Forage and protein sources had little if any effect on body weight and rumen pH indicating that the rumen function of cows fed these diets was normal. Effects of dietary treatments on milk production and feed intake are presented in Table 1. Cows on the low UIP diets ate more feed than cows on the high UIP diets regardless of the forage source.

Cows on the cottonseed hull diets ate more feed than those fed diets containing all corn silage, 10% alfalfa hay, or 10% bermudagrass hay. Cows consuming cottonseed hull diets produced more milk when they were fed high UIP than low UIP sources. This did not occur for other forage sources. Although there were some variations, neither forage nor protein supplement had a clear effect on butterfat content. The high UIP sources caused a depression of milk protein when cows were fed diets with 10% hay or cottonseed hulls.

Because the addition of 10% cottonseed hulls with the high UIP diet enhanced feed intake and milk production, a second study using 54 mid-lactation cows was conducted to evaluate the effect of higher levels of cottonseed hull with low or high UIP sources. Dietary treatments were (1) 10% cottonseed hull and 36-38% corn silage, (2) 20% cottonseed hull and 16-19% corn silage, and (3) 30% cottonseed hull and no corn silage. All diets were equal in crude protein (16.0%), energy (NEL, 0.74 Mcal per pound), and mineral contents. As in study 1, cows in each forage source were fed either low or high UIP sources.

Neither the forage nor the protein source had much effect on changes in body weight or rumen pH; however, they did affect dry matter intake, milk yield, milk composition, and blood urea nitrogen (Table 2). As the amount of cottonseed hulls in the diet increased, dry matter intake increased, but there was no increase in milk production. Cows on high UIP diets consumed less feed than those on the low UIP diets, yet they produced more milk than those fed low UIP sources. Cows on high UIP sources produced milk with lower butterfat content and depressed milk protein when cows were fed diets with 30% cottonseed hulls. The lower blood urea nitrogen values for the cows on high UIP diets may indicate better utilization of the protein fed.

Table 1. Effect of Forage Source on Dairy Cow Performance When Diets Contain Low or High Undegraded Intake Protein (UIP) Sources (Study 1)[1]

Protein and forage sources	DMI	MY	BF	MP
	lb./day	*lb./day*	*pct.*	*pct.*
Low UIP sources				
All corn silage	47.5	67.1	2.83	3.02
10% BGH	49.5	66.2	3.28	3.21
10% AH	52.8	73.0	2.78	2.98
10% CSH	60.3	64.9	3.09	3.23
High UIP sources				
All corn silage	45.9	65.1	3.00	3.01
10% BGH	45.3	71.1	2.94	2.94
10% AH	48.2	68.6	2.99	3.05
10% CSH	58.7	72.4	2.78	3.03
SEM	0.41	0.44	0.14	0.07

[1]DMI = dry matter intake, MY = milk yield, BF = butterfat, MP = milk protein, UIP = undegraded intake protein, BGH = bermudagrass hay, AH = alfalfa hay, and CSH = cottonseed hulls.

Table 2. Effect of Different Levels of Cottonseed Hulls and Type of Protein on Lactating Cow Performance (Study 2)[1]

Protein source	DMI	MY	BF	MP	BUN
CSH content	*lb./day*	*lb./day*	*pct.*	*pct.*	*mg/dl*
Low UIP Source					
10% CSH	46.9	57.6	3.19	3.12	11.0
20% CSH	53.5	59.0	3.11	3.27	14.5
30% CSH	56.5	57.6	3.17	3.28	15.0
High UIP Source					
10% CSH	41.4	60.5	3.20	3.10	10.0
20% CSH	47.3	64.9	3.19	3.11	10.8
30% CSH	50.2	64.2	3.06	3.04	11.0
SEM	0.5	0.4	0.04	0.05	0.6

[1]DMI = dry matter intake, MY = milk yield, BF = butterfat, MP = milk protein, BUN = blood urea nitrogen, and CSH = cottonseed hulls.

Based on these results, it appears that cottonseed hulls provide several advantages for dairy producers. Data indicate that cows may produce as well when receiving cottonseed hulls as corn silage if the diets are well balanced. Feeding high UIP sources, such as feather or blood meal, with cottonseed hulls produced more milk than only soybean meal when fed with cottonseed hulls. Therefore, producers should consider feeding some cottonseed hulls with higher amounts of UIP.

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Cows in the Mist

Misting System an Efficient Way to Keep Dairy Cattle Cool

John C. Lin, B.R. "Pete" Moss, Joe L. Koon, Cliff A. Flood, and Robert C. Smith,III

KEEPING COWS COOL during hot, humid weather is a critical concern for southern dairy producers because hot cows eat less and, thus, produce less milk. AAES research is showing that misting systems are economical and efficient approaches for keeping dairy cattle cool and comfortable.

Producers have several options for cooling cattle, including the use of fans, sprayers, misters, or combinations of these approaches. Systems that use water in the cooling process have proven effective; however using water in the dairy barn can be expensive and also contribute to problems with runoff from dairy facilities. AAES researchers have been evaluating various cooling systems to determine which ones are most efficient and effective for Alabama producers.

Studies were conducted at the E.V. Smith Research Center Dairy Unit in Shorter during the summers of 1994 and 1995 to evaluate the effects of different cooling treatments on lactating Holsteins. Cows (48 in the first year, 52 in the second year) were assigned to one of four treatment groups: (A) limited time in the barn with fans, (B) in the barn with fans only, (C) in the barn with fans plus direct spray, or (D) in the barn with fans plus water misters.

Cows in treatment A stayed outside from 6-9 a.m. and 5 p.m.-1 a.m. daily. Cows in the other treatments remained inside except for two hours of outside exercise daily. In each treatment, two Turbo-Aire fans were mounted every 25 feet and ran continuously when air temperature exceeded 78°F. Fans used for treatments A, B, and C were placed eight feet from the ground both years of the study. In 1994, fans for treatment D were placed 10 feet high, but lowered to seven feet in 1995 because, in the first year, mist was caught in updrafts and carried out of the barn through roof vents. Therefore, it did not reach the backs of cows.

Cows under the misting system at E. V. Smith Dairy Unit.

The direct-spray system (treatment C) consisted of five 0.0625-inch diameter, solid-cone low-pressure nozzles (Senninger 180°, Model #9; 1.77 GPM at 10 psi) mounted on half-inch PVC pipe installed along the feed bunk at a height of six feet, two inches and spaced about seven feet, six inches apart. Sprayers were turned on automatically for three minutes of every 15 minutes whenever the temperature was above 82°F. For treatment D, each fan was equipped with circular tubing that contained four hollow cone nozzles (0.016 in. diameter; 1.2 GPH at 60 psi). In addition, a 10-foot bar with four similar nozzles was placed in the front of each fan. Misters around the fans and on the bar were turned on automatically when the temperature exceeded 82°F and 85°F, respectively.

The outside temperature during the test periods (June, July, and August) of both years, especially during 1995, was very high with many day-time temperatures of 95° to 100°F and night time temperatures of 75°F. Temperatures and humidities of both years were determined for the four different treatments (see the table). Temperatures were not different between the direct spray and mister areas, but both were lower than the area where only fans were placed. As expected, the relative humidity was higher for areas with direct spray or misters than the areas with fans only.

Cows seemed to be more comfortable in the areas with direct spray or mist. To determine this, the respiration (breathing) rate was counted as flank movement of five cows per group each

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week. Cows in groups without any water cooling had to breathe more often to keep cool than did cows in the spray or mist systems.

Individual feed intake was determined through group feed consumption divided by number of cows in the group. In both years, cows under the direct spray and misters consumed more feed than those with only dry fans. However, there were no differences in milk production between cows under misters and those under dry fans in 1994. In 1995, the feed dry matter intake was about five pounds more per day (13% higher) for cows in the direct spray-fan and mist-fan treatment areas than for cows in the other two treatments. Milk yield was about seven pounds more per day (15.3% greater) for cows with water systems compared to cows without the water cooling treatments.

There were no differences in daily milk production between cows in the direct spray-fan (52.8 pounds) and the mist-fan (53.2 pounds) treatments, when the misters were lowered. Milk fat percentage was lower for treatment A cows allowed outside for extended time each day in 1994, but did not differ among the treatments in 1995. Milk protein was lower for those treatment A cows allowed outside for longer periods in 1995. Body weight gains did not differ among the treatments in 1994, although there were some slight differences in 1995. The mister system used much less water than the direct spray system in both years.

These results indicate that cooling cows with water applied through either a mist or spray can increase milk production if the system is installed properly. Overall, the combination of mister and fan cooling system provided the best choice of this study, because water use and wastewaterrunoff were reduced compared to the spray system.

Environment and Response of Dairy Cows Under Various Cooling Regimes During Two Summers

	Cooling treatments				SEM
	A:Inside Outside	B:Inside Dry fan	C:Inside Direct spray	D:Inside Mister	
Maximum temperature °F					
1994	82.8	82.2	77.9	78.6	0.97
1995	88.5	88.7	81.5	80.1	1.15
Humidity (%)					
1994	66.4	68.3	84.3	81.0	3.25
1995	69.8	69.5	93.9	88.5	3.32
Respiration rates/min.					
1994	67	66	54	57	2.92
1995	76	77	58	66	2.99
Dry matter intake (lb./day)					
1994	37.4	37.6	41.8	40.7	0.59
1995	39.6	38.5	45.1	43.1	0.75
Milk yield (lb./day)					
1994	51.0	49.3	55.0	50.6	1.25
1995	45.8	46.2	52.8	53.2	1.17
Milk composition					
Fat (%)					
1994	3.40	3.50	3.50	3.60	0.06
1995	2.96	2.88	2.76	2.98	0.14
Protein (%)					
1994	3.40	3.50	3.30	3.30	0.04
1995	3.17	3.38	3.39	3.34	0.05
Body weight gains (lb./day)					
1994	1.34	1.10	1.52	1.83	0.13
1995	0.92	1.32	1.08	0.53	0.20
Water used (gal./cow/day)					
1994	——	——	41.5	3.2	
1995	——	——	120.8	11.9	

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