U.S. Department of Agriculture Agricultural Research Service Vol. 34, No. 10, November/December 1986

Agricultural Research

Ozone Robs Yields

Story on page 6.

Research: Starting Point for Action

Many agencies, both public and private, share the responsibility for protecting America's supply of food and fiber from field to table. At the federal level, these organizations are usually called action agencies, because they carry out specific programs to eradicate an insect pest, to control soil erosion, or to ensure quality and safety of agricultural commodities.

Examples of action agencies within USDA are the Animal and Plant Health Inspection Service, Federal Grain Inspection Service, Food Safety and Inspection Service, and Soil Conservation Service. Each is supported in its mission by the nation's largest agricultural research organization—the Agricultural Research Service. We have no more important responsibility than to conduct research for these action agencies. Our task is to help solve problems that may deter them from achieving their goals. It is in this way that we best serve farmers and ranchers and consumers.

To carry out our mission, ARS employs some 2,700 scientists at 137 locations in the United States and abroad. Entomologists, soil scientists, chemists, agronomists, and representatives of more than a score of other scientific disciplines are seeking—and finding—answers that the action agencies can put to practical use.

More often than not, ARS research undergoes trials in the field, in cooperation with the action agencies and often with state agencies, universities and experiment stations, farmers and ranchers, and industry.

Results from these cooperative relationships have gone a long way toward solving many serious problems, such as:

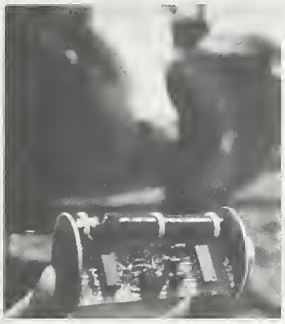
- *The screwworm fly.* When this costly pest infested American livestock in the South and Southwest, an ARS scientist devised an original way to eradicate it: turning the screwworm's reproductive ability into a weapon. Billions of male flies sterilized by radiation were released to mate with native females, each of which mates only once. The sterile males so outnumbered native males that few offspring were produced. The procedure was repeated until the screwworm was gone from the United States. Today the battle continues in southern Mexico.
- *Africanized bees.* These aggressive bees, expected to reach Texas and Arizona by 1988-92, produce little honey and are more likely to sting than European strains common in the United States. ARS has developed easy-to-use identification tests so field technicians can distinguish Africanized bees from other strains. ARS is working with Animal and Plant Health Inspection Service experts to develop a barrier zone in Mexico to stop them from spreading into the United States. This barrier plan will include trapping bees, baiting hives to kill Africanized swarms, close monitoring and inspection of hives, and other measures.
- *The boll weevil.* This cotton pest has been largely eradicated in the Carolinas by an ARS-developed insect control technology—a combination of traps, pesticides, and other practices. The program may be extended to other cotton states as well.
- *Trichinosis in swine.* Our scientists have developed a blood test that detects this parasitic disease in pigs with 95-percent accuracy.
- *Grain quality.* ARS developed rapid methods for measuring protein content and hardness of wheat, a key to grading and pricing. We have also pioneered the use of in-transit fumigation of U.S. grain destined for foreign countries.
- *Food safety.* ARS is studying sodium (a component of table salt) and nitrites, two substances used to control food-poisoning bacteria. Since these substances have recently raised health concerns, our scientists are studying how much sodium and nitrite can be removed without allowing bacteria to grow. And to help the meat industry and federal regulators ensure product safety, we have developed guidelines on cooling requirements for meat and on time and temperatures for thawing red meat. These precautions will also help industry and consumers control the growth of bacteria that could cause food poisoning.
- *Wind and water erosion.* Research includes developing a better understanding of how erosion affects production and how conservation tillage affects the soil environment. Also in the works are improved equations for predicting soil erosion.

By working together on these and other problems, we help USDA action agencies carry out their mission of protecting our food and natural resources.

Terry B. Kinney, Jr. Administrator

Agricultural Research

Cover: ARS plant pathologist Allen Heagle (right) and Walter Pursley discuss progress of study on air pollution's effects on soybeans. So far, they've found that the more soil moisture there is the more ozone plants absorb. Story begins on page 6. (0986X1055-25A)



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Corn's Wild Cousin Undergoes Sex Change

A wild relative of corn called eastern gamagrass has undergone a sex change that could offer farmers a new grain crop.

In one variant of the gamagrass, male flowers have turned female and started doing what female flowers do best—producing seed.

"Our research here shows that with both the male and female parts producing seed, production on each seed head has increased by about 2,500 percent," says Chester L. Dewald, a USDA Agricultural Research Service agronomist in Woodward, OK.

Because eastern gamagrass seeds have protein—even more than corn—it could become a nutritious grain crop to be eaten by both livestock and people.

Eastern gamagrass, which flourishes in the southeastern states and Mexico, is a bunchgrass ranging in color from green to brown. It can grow 6 to 8 feet tall.

Dewald says, "We have a long way to go before we finish breeding the grass for human or livestock use, but it can definitely be done."

He has already bred a gamagrass line that produces twice as much seed as the original variant.

The variant, whose stalk and leaves resemble those of corn, originally showed up in a nursery at the Plant Materials Center of the USDA Soil Conservation Service in Manhattan, KS. Robert Dayton, who was manager of the center at the time, had planted what he thought were normal eastern gamagrass seeds. When the plants grew, he recognized that one of them was very different from the rest and contacted Dewald at the Southern Plains Range Research Station.

Dewald later found the variant growing in the wild in Ottawa County, KS.

"We think the mutation is a throwback to when all flowers on the plant performed both functions," Dewald says. The gene or genes that "ordered" all parts to do both jobs had been lying dormant for years and just began controlling the plant again.

Dewald adds that the discovery may reveal the secret behind corn's evolution. "Close relatives often undergo similar mutations, so perhaps this indicates that corn changed into a prolific grain producer in one step, with one mutation."

Confirmation of Dewald's suspicion could rewrite chapters of evolutionary botany, because scientists have traditionally thought corn's transformation into a prolific grain producer was very gradual, over thousands of years.—By **Jessica Morrison,** ARS.

Chester L. Dewald is at the USDA-ARS Southern Plains Range Research Station, 2000 18th Street, Woodward, OK 73801. ■

Agronomist Chester Dewald inspects seed heads of eastern gamagrass variant. (0686X737-9)

CAT Scanning Farm Animals

A sophisticated tool used in human medicine may help select livestock of the future with just the right amount of fat for consumers.

Kreg A. Leymaster, an animal geneticist with the USDA Agricultural Research Service in Nebraska, believes the CAT (computer-assisted tomography) scan may be just the tool for livestock scientists.

Preliminary results from experiments Leymaster helped conduct at the Agricultural University of Norway "are quite encouraging," Leymaster says.

CAT scanners are commonly used in medicine as a diagnostic tool. The cross-sectional images, constructed from X-ray data, may provide animal researchers a way to assess the amount of lean meat without slaughtering the animal.

Leymaster says, "After seeing inside the living animals in this way, researchers can save for breeding those animals judged as genetically superior."

The goal is to produce meat that is lean as well as tender and tasty.—By **Ben Hardin,** ARS.

Kreg A. Leymaster is at the Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, NE. 68933 ■

Test-Tube Intestines

Thin sections of pig intestine can now be kept alive and functioning in test tubes for 5 days or more after being removed from the animal.

This feat offers new insights on how intestines respond to viruses, drugs, toxic materials, and the first milk (colostrum) that mammals produce after giving birth.

Phletus P. Williams, a USDA Agricultural Research Service microbiologist at the National Animal Disease Center, Ames, IA, developed the technique. Before now, no intestinal organ samples from people or animals have been kept in good condition for more than 3 hours.

A key feature of Williams' technique is alternating between rinsing the tissue and exposing it to a carbon dioxide-air atmosphere. The rinse solution contains nutrients and antibiotics. The sample is rotated in a glass tube 12 times per hour.

Williams places a section of the intestine, inside out, over a rectangular surgical sponge. This positioning enhances cleaning of the intestine's mucous membrane by the gentle rinsing. The rectangular shaping helps the researcher locate sites for detailed examinations through scanning and transmission electron microscopes. Morever, the inside-out orientation means the cell lining of the intestinal tract can then be observed easily and the penetration, movement, and effects of test materials can be checked.

"Such observations are difficult or impossible in an intact animal," Williams says.

In addition to studies with viral pathogens that cause transmissible gastroenteritis (diarrhea) and pseudorabies, Williams has demonstrated for the first time the moving of colostral cells through the lining of intestines taken from newborn pigs.

Colostrum, which passes from the gastrointestinal tract to the bloodstream of a newborn, is composed of secretions formed in the sow's mammary glands before normal lactation. It is packed with proteins, vitamins, and antibodies.

Williams exposed different sections of intestine to colostrum he had treated with a fluorescent marker and examined them under a microscope. He determined that the first and second divisions of piglet intestine transport colostral cells through to the bloodstream for about 24 hours after birth. Then the intestinal lining thickens and prevents cell transport.

Pigs, unlike people and some animals, do not receive antibodies before birth from the mother through the wall of her uterus.

Because the first milk is so critical to the survival of piglets, Williams says, knowing how and when colostral cells and antibodies move into the bloodstream may lead to new methods for preventing deaths among newborn pigs.—By **Ben Hardin,** ARS and **Ray Pierce,** ARS (retired).

Phletus P. Williams is in Virology Swine Research, USDA-ARS National Animal Disease Center, P.O. Box 70, Ames, IA 50010. ■

More Beef Per Acre

Cattle are smart enough to know when it's time to switch from old grass to the feeding trough. This self-regulating ability can be exploited by farmers who want to feed more animals per acre.

Cattle on bermudagrass pasture are observed by animal nutritionists William Phillips, ARS, (left) and Gerald Horn, Oklahoma State University. The number of cattle per acre is varied to determine the most efficient system for producing beef. (0786X771-4)

Of course, before farmers can decide whether to do this, they'll need to know how much it's going to cost them in extra feed.

Information on feed costs is especially critical to those farmers in the Southern Great Plains who keep cattle from about June 1 through October 1—the growing season of pasture grasses such as bermudagrass.

With these farmers in mind, animal nutritionists William A. Phillips, Agricultural Research Service, and Gerald W. Horn, Oklahoma State University, ran a 5-year study of steers grazing bermudagrass.

They tested three levels of grazing—the equivalent of two, three, and four 500-pound steers per acre. In all three systems, the nutritionists provided supplemental feed when bermudagrass was limited during the 4-month grazing season each year.

They found that the system with the fewest animals per acre, a low-risk system, pretty much guarantees farmers that they can depend on grass to provide all the feed. If it's a good rainfall season they even have enough grass for a hay crop. That's why most farmers choose this system—it's the safest way to go in the semiarid plains of Oklahoma and requires no additional feed inputs with additional cost.

But the nutritionists found it's not the most efficient way to produce beef because it wastes good quality grass. The medium-risk (3 animals/acre) and high-risk (4 animals/acre) systems make for more nutritious forage because they keep the grass in a constant regrowth stage, rather than letting it mature to a poorer quality forage.

These systems do maximize the utilization of the grass but require supplemental feeds which can be purchased or grown by the producer.

The success of the higher risk systems and the protection of the pasture depended on the availability of supplemental feed.

Finding out how much silage was needed required a trial-and-error method and some waste of silage at first, but now with all the data in, the scientists can tell farmers how much extra feed steers will eat—on a daily basis—and how much weight they will gain.—By **Don Comis,** ARS.

William A. Phillips is at the USDA-ARS Forage and Livestock Research Laboratory, El Reno, OK 73036. Gerald W. Horn is at Oklahoma State University, Stillwater, OK 74078. ■

Research Assesses Ozone Damage to Crops

Ozone and other air pollutants are costing farmers at least $1 billion in agricultural crop losses each year, according to Agricultural Research Service scientists studying the damage.

''Farmers don't see ozone damage happening to their field crops, but it is,'' says Walter W. Heck, a plant physiologist who heads the agency's air pollution research at Raleigh, NC, in cooperation with the Environmental Protection Agency (EPA).

Damaging ozone is caused by a photochemical reaction of sunlight with automobile and industrial exhausts containing nitrogen oxides and hydrocarbons. It is different from the ozone layer in the Earth's stratosphere that filters out ultraviolet sunlight but does not harm crops.

''Ozone is carried by prevailing winds, often for hundreds or thousands of miles,'' Heck says. ''That's why rural areas, despite having fewer automobiles and industrial plants, often equal the ozone pollution levels for urban areas.''

As a result, he says, crops far away from pollution sources are not necessarily safe from ozone.

''We see in field-test chambers and in greenhouses that ozone is causing leaves of soybean, wheat, cotton, peanut, and other agricultural crops to die prematurely, reducing yields and costing the farmer money,'' he says. ''And the $1 billion figure doesn't include damage to horticultural crops and to forests.''

Yield losses are based on crop studies done at sites across the country from 1980 to 1982. Findings from 1983 to 1985 are being analyzed, Heck says, and final results are expected in 1987.

Heck's laboratory has been studying the problem since 1980 as part of the National Crop Loss Assessment Network (NCLAN), set up by EPA to get estimates of agricultural crop losses from ozone and other air pollutants.

A typical long-term concentration, or level, of surface ozone is 0.05 ppm, Heck says. In test areas, ozone levels ranged from about 0.04 to 0.06 ppm during a 7-hour day, from 9 a.m. to 4 p.m.

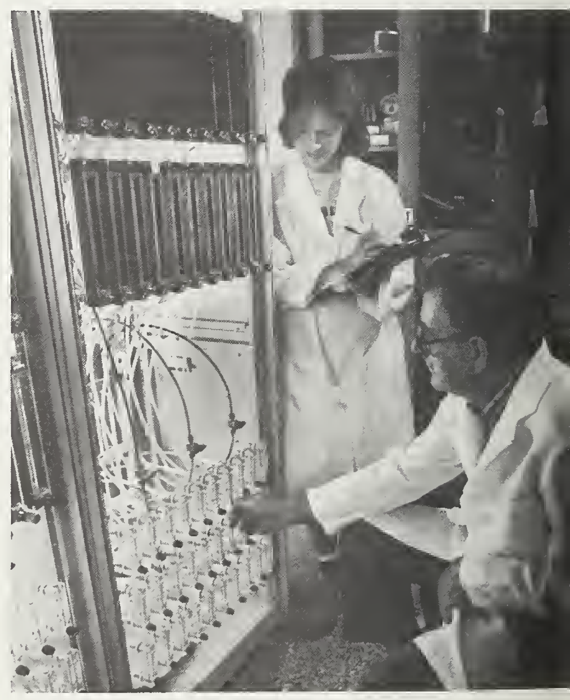
Indoor chambers control environment of snap bean plants to test response to ozone under various conditions. Plant physiologist Walter Heck and botanist John Dunning review records. (0986X1056-6)

''Ozone is carried by prevailing winds, often for hundreds or thousands of miles. That's why rural areas often equal the ozone pollution levels for urban areas.''

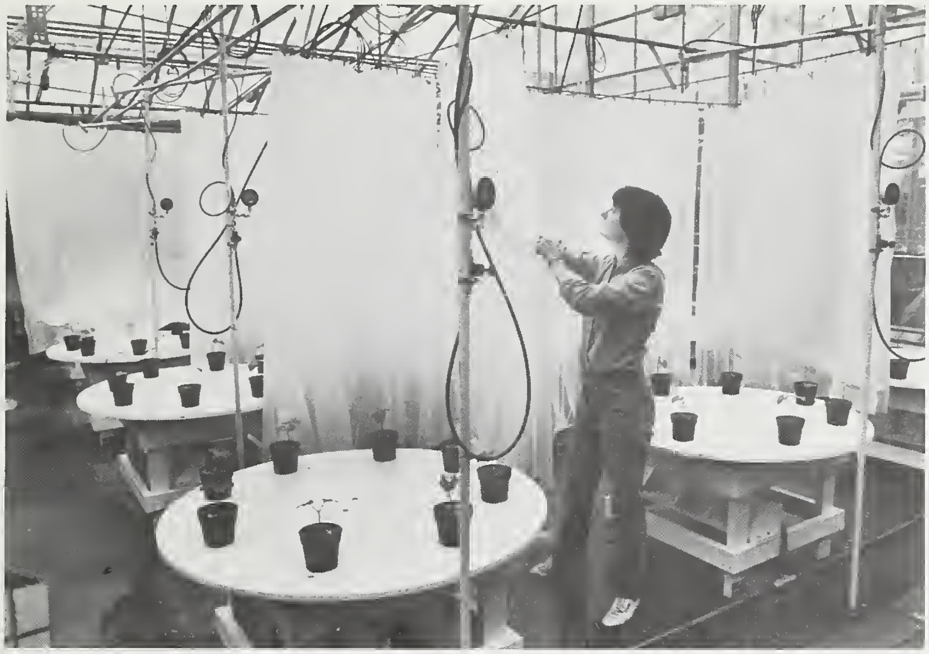
—Plant Physiologist **Walter W. Heck**

That level can significantly damage crops when plants absorb it over an entire growing season. Among the yield losses assessed to date in the NCLAN studies:

- Soybean yields decreased 12 percent when exposed to 0.05 ppm of ozone in 1980-82 field tests at Argonne, IL, Beltsville, MD [see *Agricultural Research*, November 1981, pp. 4-6], Ithaca, NY, and Raleigh.
- Peanut yields also decreased about 12 percent during 1980 tests at Raleigh. Peanut and soybean losses



Technicians Tommy Gray and Gwen Palmer check equipment that dispenses ozone and other gaseous pollutants into an adjoining greenhouse. (0986X1056-20)



Acid rain's about to fall on test plants. Gwyn Trueblood adjusts curtains to keep plants from being splashed by neighboring showers. Tabletops rotate to ensure equal doses during simulation. (0986X1056-30)

were among the highest for crops tested.

- Cotton yields at Shafter, CA, showed a 7-percent reduction, while 1982 tests at Raleigh showed that yields of a common type of cotton grown in the South decreased by 10 percent.
- Winter wheat yields at Argonne were reduced 7 percent.
- The lowest reduction at 0.05 ppm was 1.5 percent in corn tests at Argonne in 1981 and for sorghum there in 1982.
- As ozone increased, yields declined for all the crops tested. At 0.06 ppm, for example, soybean yields were cut by 17 percent, and at 0.09 ppm, the loss was 31 percent.

The results for soybeans, cotton, winter wheat, and corn were calculated on what Heck calls a "common ozone response" of several varieties for each crop. The peanut and sorghum results were based on data from a single variety for each crop.

Heck and agency plant pathologists Richard A. Reinert and Allen S. Heagle at Raleigh are studying ozone and other air pollutants in several ways. Heagle conducts outdoor field studies in specially designed test chambers; Reinert conducts indoor studies in exposure chambers placed in greenhouses and in a building called a phytotron, where environmentally controlled rooms and compartments allow scientists to study the problem under a variety of conditions.

"We study plants at different stages of development and expose them to different factors to see what ozone does to them," says Reinert. "In the greenhouses and phytotron, we can see how temperature, light, fertilizers, moisture and other variables affect a plant's response to ozone and other air pollutants. We can also determine how other factors such as plant diseases are influenced by air pollutants."

The outdoor studies are in cylindrical, open-top chambers specially designed to gauge the effects of air pollutants on different crops.

The chambers are 10 feet in diameter and 8 feet tall, with aluminum frames surrounded by plastic. They are placed on the ground, and crops are planted inside of them. Air is pumped into them, either through charcoal filters to remove ozone, or without filters to let ozone in.

Ozone in the different chambers can be regulated so that scientists can compare plant responses at various concentrations or when ozone is filtered out.

"We've only scratched the surface at this point," Heagle says, "but we're at the point where the trends we've seen are pretty clear. Now we want to continue studying how moisture affects a plant's response to ozone. We've only done that for the past 3 years."

Moisture plays a key role, according to Heck. When a plant lacks water, its stomates, the openings in its leaves, close to retain water in the plant. This, he says, reduces the amount of ozone a plant absorbs through the stomates from the air.

"This may explain, in part, why ozone appears to affect plants more in the East, where there is more rain," Heck says. "They probably absorb more ozone, whereas in the West, drier conditions may help plants cut down on the amount of ozone they absorb—unless they are irrigated."

Ozone enters a plant as its leaves absorb carbon dioxide necessary for photosynthesis, in which plants use sunlight to form carbohydrates. When damaged by ozone, a plant's leaves age prematurely and discolor, leaf cells die, and photosynthesis and growth decrease.

"It is frustrating for growers that we don't have anything really simple to tell them that they can do about ozone pollution," Heck says.

One research option is to breed plants that have genetic resistance to ozone, he says. "Such resistance apparently exists in all crop species that have been examined."

Meanwhile, the national crop network is completing a series of field studies and will hold an international conference in Raleigh in late 1987 to discuss results and ways to deal with air pollution problems.—By **Sean Adams,** ARS.

Walter W. Heck is in USDA-ARS Air Quality Plant Growth and Development Research, Raleigh, NC 27695. ■

Animal Electronics Make Cows Bionic Bovines

Farmers and ranchers may soon electronically monitor their livestock just as routinely as computers now monitor engine functions in some modern automobiles.

Already, some dairy farmers have installed computer-controlled devices that automatically meter feed to cows based on their individual milk production records. This ensures that high-producing cows get more feed than low-producing ones.

Roger J. Gerrits, National Program Director for Animal Production and Protection, USDA Agricultural Research Service, Beltsville, MD, says, "Scientists and commercial firms are currently developing and testing several devices for research or use on farms or in animal- and food-processing plants. The sensing and imaging technology has moved very rapidly in the last 10 years. Many devices have been developed for diagnosis and early detection of human diseases, and several of these are now available for animal research at considerably reduced cost."

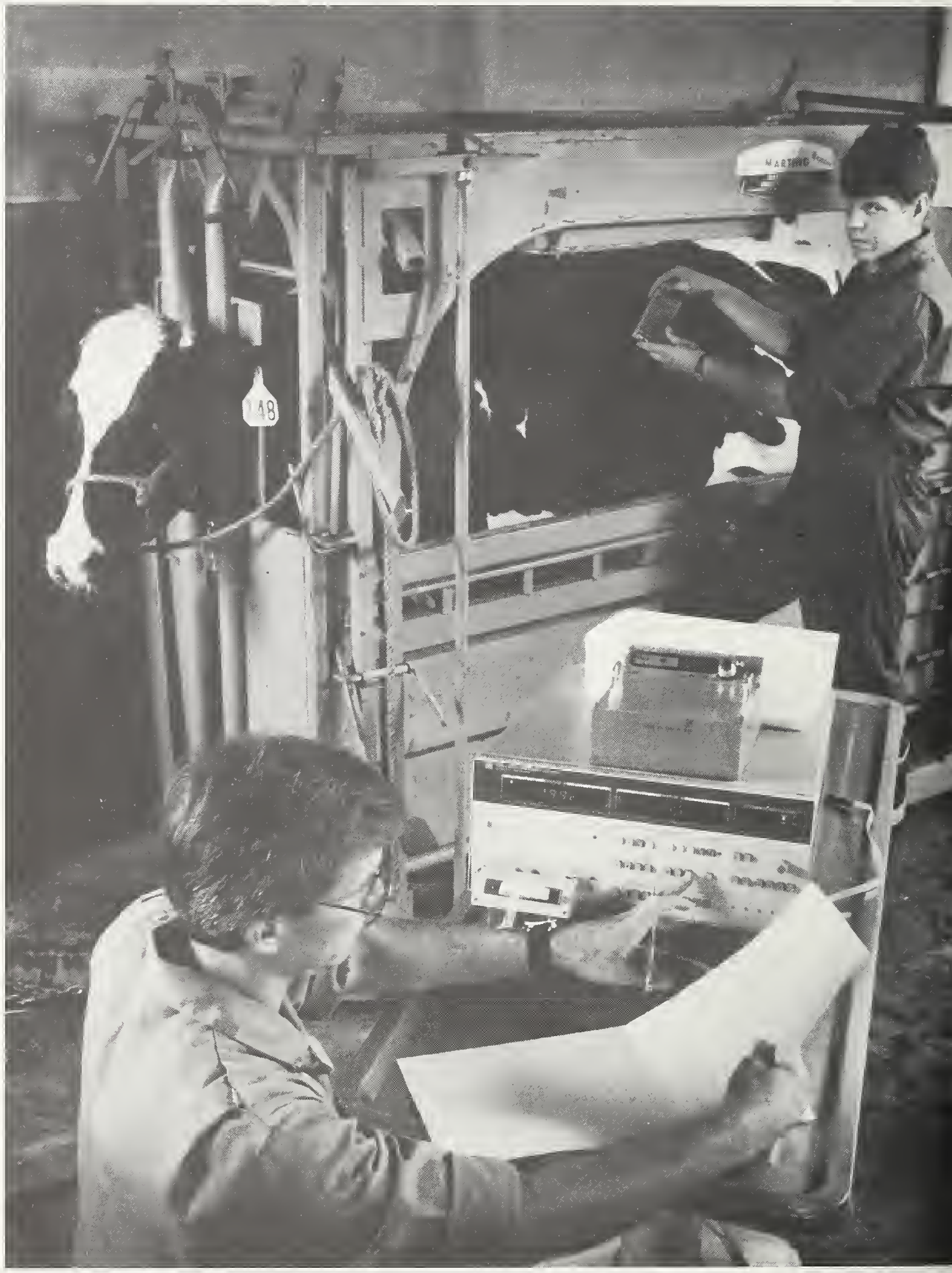
"Electronic sensors are being used to measure animal weight, carcass composition, body temperature, and fertility. We will see tremendous progress in the next 5 years in the use of sensing technology for animal identification, diagnosis or detection of diseased tissue, and the refinement of current methods that will permit electronic analysis of meat. Commercial animal- and food-processing plants will use the technology to identify quality and composition of meat."

For consumers, the new technology will ensure the quality and safety of meat products.

For producers, the technology will mean an equitable price for the delivery of high-quality products and will reduce cost of production. For example, electronic monitoring of livestock may cut losses farmers now experience due to late detection of illnesses.

Also, electronic sensors can measure an animal's weight gain from miles away. For the beef producer, rapid weight gain is of paramount economic importance. Farmers and ranchers who know which animals are lagging behind others can take steps to treat them if they are sick or cull them from the herd if they are inferior producers. Not only would culling eliminate inefficient gainers, it would help ensure that only superior genetics pass to the next generation.

But weighing livestock, especially on open ranges, is time consuming and expensive. Cattle have to be herded



Animal physiologist Gregory Lewis (seated) and biological technician Douglas Caldwell test a sensor held by Caldwell that will detect when this cow is ready to give birth. (0886X976-21) into pens and driven onto scales. The extra handling upsets livestock and can disrupt a research project.

In May 1986, ARS scientists at Miles City, MT, started testing an electronic system that automatically weighs cattle every time they come for water.

When a thirsty cow enters a small enclosure containing a water basin at the opposite end, she breaks a light beam. Much like the door operation in some grocery stores, the beam controls a gate that shuts automatically behind her. Once she is locked in the stall leisurely drinking water, the electronics go to work.

Each cow has a donut-shaped ear tag about the size and thickness of three stacked quarters. As she lowers her head to drink, the ear tag comes close to a box that emits low-level microwaves. This energy bombards the ear tag, bringing to life a miniature radio transmitter inside that broadcasts her identification number. After this ID is verified by a microcomputer, the time and date are recorded and measuring begins.

The bottom of the stall is a scale. The cow's weight is read electronically 30,000 times a second. An average of these weights, computed each second, eliminates variations caused by the cow jostling around—something similar to weight differences people can get by shifting their bodies on bathroom scales.

Other devices measure volume and weight of water each cow drinks. When the cow has finished, she starts to back out of the stall, breaking another light beam that triggers the release mechanism on the privacy gate. She returns to her pasture, and the microcomputer calibrates the scale, setting it to read zero just before the next cow enters. This eliminates errors that might occur if cows track in mud or defecate. The scale also has heating coils to keep snow or ice from accumulating in cold weather.

Researchers, 5 miles away in an office at the Fort Keogh Livestock and Range Research Station, receive the data via radio. A computer stores this data for analysis and gives information on how individual animals are faring on the range as well as overall herd performance.

Bradford W. Knapp, a statistician at the research station says, "We use repeaters that pick up the electronic signals from our seven scales, amplify their intensity, and boost them over hills that make line-of-sight transmission impossible. With more repeaters, we could collect information from the very edges of our 55,000-acre experimental ranch—some 8 miles distant."

"Our system is 'water driven,' meaning the cow's reward for entering the stall is a drink. It can be modified so the treat is a feed supplement when the research requires it," says Don C. Adams, a range nutrition scientist.

"We will see tremendous progress in the next 5 years in the use of sensing technology for animal identification, diagnosis and detection of disease..."

—**Roger J. Gerrits,** National Program Director for Animal Production and Protection

Adams and another range scientist, Pat O. Currie, are using the new equipment to monitor cattle gains on eight summer pastures that have received various treatments to improve grass growth. Currie developed the pastures with a machine that, in a single pass, can till, build water-retaining furrows with small dams, and apply fertilizer and seed. (See *Agricultural Research,* October 1983, pp. 8-9.)

The pastures obviously look better, Currie says, but the true value of rangeland improvement is how much faster cattle gain weight. In a study just begun, all pasture treatments are helping the cattle gain weight faster compared with regular pastures. Further studies will show which boosts weights the most. Then the scientists will be able to tell ranchers how they can improve their own cattle operations.

The weighing system at Fort Keogh is portable, and scientists intend to move it to winter pastures to check performance of cattle receiving supplemental feed. At the same time, Adams and Currie will study how harsh winter weather affects cattle. A weather station hooked to the remote weighing system automatically measures such things as temperature, barometric pressure, windspeed, and humidity.

In New Mexico, near Las Cruces, at the 193,000-acre ARS Jornada Experimental Range, another system is helping scientists monitor beef cattle growth on desertlike rangeland.

The Las Cruces scientists want to learn how much supplemental feed should be given livestock and when it is most helpful. This information will be useful to ranchers with similar rangeland in western Texas, southern New Mexico, and southeastern Arizona.

Cattle have a tough time getting enough to eat on arid rangeland. Each cow often has to graze 2 to 3 acres every day in the winter. And when there isn't enough rain in the fall and spring, there may be little or no green forage for them.

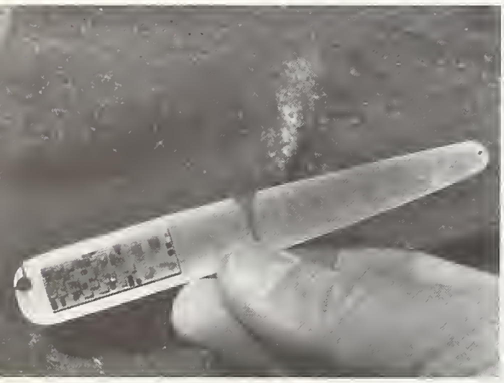
The scientists are using the equipment to electronically identify and sort about 100 head of cattle into 3 groups every time they come in for water. Two of the three groups receive cottonseed meal to supplement their range diet.

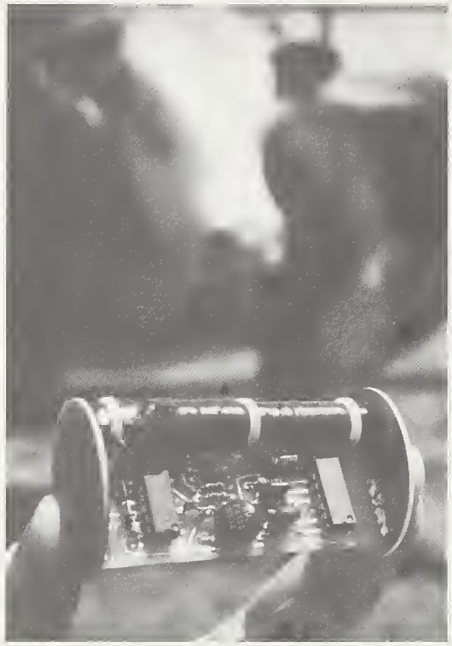
"By having the three groups graze the same range, we eliminate the effect different pastures might have on our results. Thanks to the electronic equipment, we can quickly and cheaply separate the groups at feeding time," says range scientist Dean M. Anderson.

USDA's Animal and Plant Health Inspection Service, in cooperation with the Los Alamos National Laboratory, Los Alamos, NM, developed the electronic identification system, and ARS scientists integrated it with an electronic weighing system.

Weights are not the only bovine secrets being exposed by ARS electronic surveillance—implanted electronic sensors have proven more than 90 per-

Animal Electronics Make Cows Bionic Bovines





Two types of electronic transponders identify the animals wearing them. One (top left) is implanted under the animal's skin. A similar unit (top right) is encased in plastic and worn around the animal's neck. Each contains a miniature radio transmitter that broadcasts an identification number to a computer. (Top left photo, 0586X576-27; Top right, 0586X575-33)

Above: Range scientist Dean Anderson reviews weights for beef cattle separated into three groups—two with supplemental feed and one without—collected as cattle move through the electronic weighing system. (0586X579-22)

cent accurate in detecting when cows are ready for mating.

The sensors also predict when cows will give birth. This will help cut cow and calf deaths. If farmers know when the calf is due, they can be present to assist in difficult deliveries.

In Maryland at the Beltsville Agricultural Research Center, biomedical engineer Alan Marc Lefcourt says, "The key to these sensors' operation is resistance of reproductive tissue to small electrical pulses, about one-twelfth of the 5-milliamp current used in most human heart pacemakers. When a cow is in heat, these tissues swell with water, making them less resistant to the current. This information is relayed electronically to a recording device."

Currently, dairy farmers must rely on cow behavior, such as restlessness, to signal that it's time for breeding. If dairy farmers miss these clues, which they do half of the time, it costs them money—an estimated $300 per year for each cow in the herd.

The sensors and monitoring electronics, if commercially mass-produced, coupled with a standard computer, shouldn't cost the farmer more than $30 per cow per year. The equipment cost is minimal compared with the expense of feeding an unproductive dairy cow 21 more days (the length of the estrous cycle) for each breeding time missed—and paying another breeding fee.

Gregory S. Lewis, an ARS animal physiologist in Beltsville, MD, and Eliezer Alzinbud, an Israeli scientist, cooperated in developing these sensors in a joint project supported by the U.S.-Israel Binational Agricultural Research Development Fund.

In Ames, IA, at the National Animal Disease Center, electronic engineer Joseph L. Riley has a sensor and radio transmitter to check stomach wall movements or contractions in cattle.

Riley says, "The unit is encased in a capsule small enough to be placed in the rumen through a stomach tube. It will broadcast readings on the rumen's response to feed toxins or to diseases for about 2 months, depending on the life of the batteries."

Animal electronic sensors coupled with computer technology have been largely research tools in the study of animal physiology and behavior to date, but the information gained will lead to practical uses for farmers and ranchers in the future.

"We can expect commercial interests to eventually offer some of these animal electronics to the livestock industry. The prices should fall just as we saw pocket calculators fall in price from several hundred dollars to sometimes giveaway sales gimmicks," says Gerrits. "There is little question that this equipment could become as commonplace on animals as electronic wristwatches have become on people."—By **Dennis Senft,** ARS.

Roger J. Gerrits is on the USDA-ARS National Program Staff, Bldg. 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705. ■

Senepol: New Strain for Subtropical Herds

Senepol, a Caribbean breed of beef cattle that is relatively new to the United States, shows promise of becoming a desirable addition to breeding programs from coastal Texas to the Carolinas.

The placid cattle, which range in color from tan to dark red, were originally bred in 1918 on the island of St. Croix, in the U.S. Virgin Islands.

They were the result of a cross of Red Poll, an English breed, with N'Dama, a humpless longhorn from West Africa. The hornless, humpless breed that resulted—Senepol—adapted well to the island's tropical environment, tolerating ticks, insects, hot weather, and a wide range of rainfall.

They were able to graze through the hottest part of the day and maintain acceptable levels of production during dry spells.

Until the late 1970's, Senepol were largely confined to St. Croix. Since then, however, small numbers of Senepol have been imported into the United States, most of them to Florida and Tennessee.

Until the first Senepol-sired calves were born on USDA Agricultural Research Service property in Florida in 1978, all the cattle in this country that were adapted to life in the subtropics contained Zebu blood, a species *(Bos indicus)* with a characteristic hump. The most familiar Zebu representative to Americans is the Brahman, an ill-tempered animal that has been an irreplaceable part of every subtropical breeding program in the United States.

A different strain of cattle with similar adaptation, like Senepol of the *Bos taurus* species, should prove healthy for southern crossbred herds, bringing with it hybrid vigor as well as other desirable features, such as a gentle disposition.

USDA trials of Senepol cattle have been conducted since 1978 at the Subtropical Agricultural Research Station, a 4,000-acre ranch at Brooksville, FL, a few miles north of Tampa. The first research with Senepol at Brooksville was to determine whether the breed would transmit its tropical adaptation to a crossbred animal in a new environment. The study was carried out under the direction of Will T. Butts, an ARS geneticist, in cooperation with the University of Florida.

For his research project, Butts compared the performance of a crossbred Senepol-Angus herd with the more familiar Brahman-Angus crosses.

"Overall," says Butts, "performance of both crossbreeds under subtropical conditions was excellent." The tropical adaptation, he added, proved "definitely a genetic thing, with the adaptation mechanisms transmitted intact to the Senepol crosses, just as they have been to Brahman crosses."

Further, while the bahiagrass grazing around the station, "is anything but top quality feed," Butts says that weight gains of both crossbreeds, considering all the factors, have been "all that anyone could hope for."

Representative of a breed that is gentle, intelligent, and responsive to handling, a Senepol cow is a good mother, calving unassisted on the range and producing plenty of milk for fast weight gains. (0386X408-9A)

Other promising features of the Senepol crosses in a subtropical environment include good calf and milk production, an excellent record of unassisted calving, and early maturity. In St. Croix, a Senepol cow often produces 13 to 15 calves in her lifetime. Somewhat leaner than Brahman-Angus crosses, Senepol-Angus crosses produce carcasses of a slightly higher quality grade than those from the Brahman-Angus. Offspring weaning weights and carcass weights are similar for the two crossbred groups, indicating similar production efficiencies. (See table.)

So far, reports Butts, only about 1,500 Senepol cows are registered worldwide, but counting calves, "the world population could be as high as 3,000 to 4,000."

"It's not a common breed," says Butts. "Not yet. But it's got a lot going for it."—By **Hubert Kelley,** ARS.

Will T. Butts is at the USDA-ARS Subtropical Agricultural Research Station, P.O. Box 246, Brooksville, FL 34298. ■

Characteristics of calves and steers from Senepol-Angus and Brahman-Angus cows[1]

	Senepol-Angus	*Brahman-Angus*
Number calves weaned	21	22
Birth weight of calves (lbs)	74	69
Weaning weight of calves, adjusted to 205 days (lbs)	584	600
Cow weight at weaning (lbs)	1,087	1,143
Number of steers	9	7
Steers, days on feed	184	184
Steer carcass weight (lbs)	788	806
Steer carcass weight per 1,000 lbs. of cow weight	725	705
Steer carcass fat (inches)	0.45	0.52

[1]Calves sired by Simmental bulls. Performance of calves, born in 1984, is representative of that observed throughout the study. Source: Will T. Butts, Agricultural Research Service.

Computer Keeps Potatoes Breathing Easy

Agricultural engineer Lewis Schaper inspects vertical and horizontal air sampling tubes during bin-filling operation. (1086X1152-27)

When a 500-ton bin of potatoes is about to rot, storage managers need to take action in a hurry.

Now a new computerized system developed by USDA Agricultural Research Service scientists at East Grand Forks, MN, can give them a hand in deciding which action is best.

Researchers at the Red River Valley Potato Research Laboratory have linked a personal computer to gas monitoring devices, temperature and wind sensors, and ventilating fans to give early warning of spoilage or other storage problems.

The computer system helps most in controlling bin atmospheres during and soon after harvest. That's when potatoes recover from harvest damage and use large amounts of oxygen and produce high concentrations of carbon dioxide. Normal respiration in the dark conditions adds to a bin environment that promotes the outbreak of disease. ''Disease micro-organisms love an anaerobic atmosphere where they have the advantage of living and growing without oxygen,'' says biochemist Jerry L. Varns.

Storage managers provide needed oxygen for the potatoes by forcing outside air into bins through ducts connected to an electric fan. Ventilation helps potatoes suberize, or cure. This process, which takes about 2 weeks, toughens potato skins and heals wounds inflicted by handling during harvest.

But the decision of how much ventilation to use is not as simple as it may seem. The bins used for potatoes intended for potato chips are typically 25 feet wide by 80 feet long. Potatoes are normally piled 16 to 18 feet deep in these bins. Excessive fan operation supplies ''too much air too soon and causes them to shrink and flatten,'' says agricultural engineer Lewis A. Schaper. ''Those on the bottom bruise from the weight of those above them.''

Restricting air circulation too much can be harmful. Varns explains it this way, ''Potatoes are alive. In storage they use up oxygen and respire carbon dioxide. The poor tubers on the bottom of the bin are the first to show breathing problems because of the weight stress. The added stress becomes too much and that's when diseases take

Above: Biochemist Jerry Varns evaluates potato storage environment by computerized monitoring of windspeed, temperature, relative humidity, and gases released by potatoes. (1086X1150-18)

Left: Research facility at the Red River Valley Potato Research Laboratory in Minnesota contains a single commerical-size storage bin holding over 1 million pounds of potatoes, enough to feed 10,000 people for a year. (1086X1154-3)

over. They start in small areas commonly called disease pockets and, if not contained, will quickly spread by the liquid generated in these pockets."

Varns says potato bins should have sufficient ventilation to keep carbon dioxide levels from rising above 2 percent during curing. After curing, levels should be kept even lower.

Experience in managing potato storages doesn't always provide the best insurance against disease problems. That's mainly because changes in temperature, humidity, and windspeed during harvest and bin-filling can create the need for individualized management for each bin. Such attention has not been possible for the majority of farmers who both grow and store potatoes.

After the researchers tested the computerized monitoring system in a commercial-sized research bin, they installed a second, modified system at an eight-bin commercial storage facility. Air samples from over 60 locations within the bins are automatically pumped via nylon tubing to a gas chromatograph for analysis.

The chromatograph acts as a mechanical nose by identifying key stress gases in the air much sooner than a human can detect them. Also, when carbon dioxide levels get too great, the computer turns on the fans to remove the heavy concentrations. Without ventilation, or if wind conditions are calm outside of storage buildings, accumulations can easily reach unfavorable levels of 4 to 6 percent. Conversely, windspeeds exceeding 10 mph can remove accumulations and the monitoring system turns off the fans. Computerized monitoring of each bin thus helps provide disease protection and minimize water loss from excessive ventilation.

Both laboratory research and fieldwork in commercial bins are being done in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers' Association.—By **Linda Cooke-Stinson,** ARS.

Jerry L. Varns and Lewis A. Schaper are in the USDA-ARS Red River Valley Potato Research Laboratory, P.O. Box 113, East Grand Forks, MN 56721. ■

Gas Clues to Bruises

Excess carbon dioxide given off by bruised fruits and vegetables provides a telltale clue to rough treatment during picking and handling.

As a result, scientists can use carbon dioxide readings that are above normal respiration levels (for dark storage conditions) to quickly and reliably measure damage, says Clyde L. Burton, a plant pathologist with the USDA Agricultural Research Service in East Lansing, MI.

Carbon dioxide is a byproduct of the breakdown of malic acid spilled from damaged cells near the site of a bruise.

To relate carbon dioxide release to the degree of damage, Burton and technician Nancy L. Schulte-Pason dropped freshly harvested cherries and blueberries one to five times from a height of 3 feet. The impacts simulated those that might occur during harvesting and handling.

They immediately placed the dropped fruit in sealed plastic food containers. One hour later, after carbon dioxide accumulated in the containers, needles attached to the intake and exhaust lines of an infrared gas analyzer were inserted into the containers. "The gas analyzer is so sensitive to carbon dioxide that we must be careful in breathing or talking around the machine," Burton says.

The higher the amount of carbon dioxide in a sample, the greater the damage and the higher the amount of eventual decay. The test takes 2 hours compared with a wait of several days for visual observation of decay.

Burton says that information gained from testing fruit can be used to improve mechanical harvesters and the handling equipment in packing houses.

In Michigan, it is estimated that 40 to 50 percent of mechanically harvested cherries and blueberries suffer damage.—By **Linda Cooke-Stinson,** ARS.

Clyde L. Burton is in USDA-ARS Fruit and Vegetable Harvesting Research, Room 138, Plant Biology Lab., Michigan State University, East Lansing, MI 48824 ■

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PATENTS

A Tidy Way To Plant and Fertilize

A new planter attachment applies fertilizer at just the right distance from seeds and disturbs the soil about half as much as a previous USDA invention.

The device has two blades to open furrows: the lower blade is about 1/4 to 1/2 inch thick and ends in a point; the upper blade has an elongated rectangular flat leading face that is preferably 1 to 2½ inches thick.

Both blades are attached to a hollow shank that connects to planters. A tube runs from the fertilizer tank through the shank and down the trailing edge of the bottom blade. Urea ammonium nitrate flows through the tube into the lower, narrow furrow.

Seeds drop from the seeding machine through a tube into the hollow shank. There they fall out the bottom of the shank into the broad furrow cut by the upper blade.

The two-blade arrangement guarantees the necessary separation between seed and fertilizer. Fertilizer placed too close to the seed can prevent it from sprouting.

Farmers using conservation tillage can't spread their fertilizer on the surface because it gets tied up in the decomposition of crop residue. They need a machine that puts fertilizer close, but not too close, to the seeds.

They also need a planter that causes minimal soil disturbance. When this new device was tested with wheat planting in Oregon, it left soil ridges only 2½ inches high compared with the 4½-inch-high ridges left by an earlier USDA modified planting device.

For technical information, contact Dale E. Wilkins, USDA-ARS Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR 97801. *Patent Application Serial No. 06/876,047, "Method and Apparatus for Placement of Fertilizer Below Seed With Minimum Soil Disturbance."* ■

Colorful Cotton

One of many things that has held cotton back in its competition with synthetics is the difficulty of dyeing the fabric more than one color after it's made.

This new process makes multicolor dyeing more practical by treating the yarn so it can be dyed after it is made into fabric. The yarn running in one direction, usually lengthwise (warp), is treated to accept certain dyes under mildly acidic conditions. The untreated yarn running the width of the fabric (filling) will accept dyes under conventional alkaline conditions.

Current methods require dyeing the yarn before it is turned into a finished product, limiting the manufacturer's choice of color combinations.

For technical information, contact Robert J. Harper, Jr., USDA-ARS Southern Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124. *Patent Application Serial No. 878,106, "Process for Crossdyeing Cellulosic Fabrics."* ■

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