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U.S. Department of Agriculture Agricultural Research Service April 1991

Agricultural Research

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This Spud's For You

Story on Page 4

Choosing the Proper Potato

Don't bake that chipping potato—there's a good chance you'll end up eating a spud with a mealy texture. And don't grab a baker to deep-fry into potato chips; they'll turn out brown and burned-looking.

Potato varieties grown specifically for chipping need to have a higher percentage of solids than those destined for the fresh market. Potatoes grown for the fresh market are allowed to have more fructose and sucrose in them, sugars that can cause potato chips to darken.

Because each market for potatoes has its own ideal, potato producers face several baffling market-driven decisions each time they purchase seed for planting. The choices they make will affect size and shape, color and taste, skin appearance, storability, and processing properties.

Bringing forth the potato that's right for a specific region, market, or disease-resistance trait means years of mastery for breeders; with its 48 chromosomes and often-infertile flowers, the domestic potato is a stubborn subject.

Until the mid-nineteenth century, growing potatoes was a chancy endeavor; planted generation after generation, potato lines tended to lose vigor and diminish in yield. In 1851, C.E. Goodrich, a clergyman from Utica, New York, grew and improved some potatoes he received from Panama. Goodrich's resulting selection, called Garnet Chili, became the antecedent of nearly 200 named potato varieties, including several that are still grown today.

The gene pool expanded in 1925, when the first potato germplasm collection trips were made to areas in Mexico and Central and South America where the potato originated.

The need for such improved germplasm continues to this day. [See "Preserving Potato Plant Diversity" by Ben Hardin on page 7.]

When you consider all that *Solanum tuberosum,* as the potato is known scientifically, is up against, it seems remarkable that it prevails as a food staple. White grubs, grasshoppers and leafhoppers, leaf roll, *Verticillium* wilt, and late blight all take a toll. Other pest horrors include scab, mosaic virus, and the notorious Colorado potato beetle. And many a promising potato has fallen victim to hollow heart, brown center, net necrosis, and sugar-end.

Thanks to genetic engineering, *S. tuberosum* battles the odds with greater success every day. In Beltsville, Maryland, a team of ARS scientists has developed a hybrid potato plant with its own built-in natural insect repellant, leptine, effective against costly pests such as the Colorado potato beetle.

A strategy that combines judicious chemical use with a program of biological pest control—IPM (integrated pest management)—has also had a hand in improving potato culture. The potato leafhopper is the latest of several potato-ravishing insects to be targeted by a naturally occurring fungus, *Zoophthora*. This pathogen can be grown relatively easily in liquid medium. ARS researchers have also joined with Soviet scientists in Brazil, where they're looking for natural enemies of the Colorado potato beetle. For more about IPM, see this month's cover story, "Growing High-Quality Spuds Is No Small Potatoes," by Julie Corliss.

When you consider all the work that's gone on behind the scenes, lugging home that 10-pound bag from the supermarket hardly seems worth a grumble. If your grocery budget's been feeling the pinch lately and you've been dishing up more potatoes than ever, feel free to exhort your family as you spoon up the spuds:

- that a diet of nothing but whole milk and potatoes would meet virtually all of their nutritional needs. (Yes, you'll be correct, although pushing your luck.) Or simply point out that potatoes are an outstanding source of vitamin C and also contain vitamins A and B1, calcium, and protein.
- how our continuing love affair with fast food has made the french fry a veritable staple in the American diet and the potato an enhanced source of revenue for growers.
- how the balance of trade has shifted. As recently as 1980, the United States exported more fresh potatoes than were imported. Yet by 1989, we found ourselves importing about 212,000 metric tons; the same year, merely 107,000 metric tons of potatoes were exported.
- about potato's potential as a fashion statement. In 18th century France, Queen Marie Antoinette took to strutting about Paris with potato blossoms tucked behind her ear—and what goes around, comes around.

Regina Wiggen
Associate Editor

Agricultural Research

Cover: Producing high quality potatoes like this Russett Burbank is no easy job. ARS researchers along with university and Extension Service cooperators are working to develop yet bigger and better potato varieties. Photo courtesy of The Potato Board, Denver, Colorado.

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Vol. 39, No. 4
April 1991

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Agricultural Research is published monthly by the Agricultural Research Service, U.S. Department of Agriculture, Washington, DC 20250-2350.

The Secretary of Agriculture has determined that publication of this periodical is necessary in the transaction of public business required by law.

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Subscription requests should be placed with the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Please see back cover for order form.

Address magazine inquiries or comments to: The Editor, Information Staff, Room 316, Bldg. 005, 10300 Baltimore Blvd., Beltsville Agricultural Research Center-West, Beltsville, MD 20705. Telephone: (301) 344-3280. When writing to request address changes or deletions, please include a recent address label.

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Potato Research

Growing High-Quality Spuds Is No Small Potatoes

Last year, Americans chowed down about 5 billion pounds of french fries. Most of those fries came from Northwest-grown Russet Burbanks, the favorite potato of fast-food restaurants.

Characterized by their oblong shape and dark-tan skin, Russet Burbanks also make good baked potatoes. Nearly all the potatoes grown in Idaho, our number one spud-producing state, are Russet Burbanks. Idaho, Washington, and Oregon together produced half of the nation's $2 billion potato crop last year.

Growing high-quality potatoes is no easy matter. Farmers must contend with everything from virus-carrying aphids to soilborne fungi attacking their crop, while facing increased scrutiny for using chemical controls. They must also meet processor demands for large, unblemished potatoes that make golden fries and crunchy chips.

To help farmers please french-fry aficionados, ARS researchers are breeding better spuds—ones that look and taste as good as the classic Russet Burbank yet withstand environmental assaults.

One of North America's largest potato breeding programs is at Aberdeen, Idaho. Another is in Beltsville, Maryland, at the ARS Vegetable Research lab, headed by Kathleen G. Haynes.

At the Aberdeen facility, ARS breeders Joseph J. Pavek and Dennis L. Corsini have released three promising new potatoes in the past 2 years.

Two are russets, Ranger and Frontier, both for sale in supermarket produce sections or for processing into fries. The third is the smooth, round, white-skinned Gemchip, used for making potato chips.

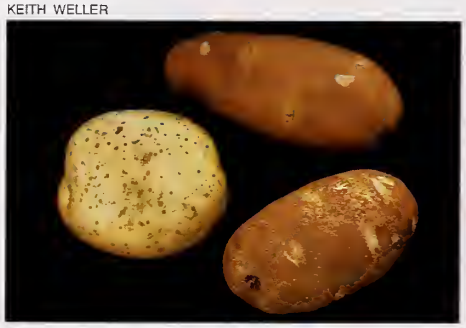
ARS, university, and cooperative extension scientists throughout the West conducted years of field trials on the new varieties. University of Idaho horticulturist Stephen Love, who works closely with Pavek and Corsini, has coordinated the trials with the Tri-State Potato Development program of Idaho, Oregon, and Washington.

KEITH WELLER

At the J. R. Simplot potato-processing plant, ARS breeders Joseph Pavek (left) and Dennis Corsini (right), University of Idaho horticulturist Steve Love (second from left), and Simplot employee Jess Lewis inspect potato strips for defects before french frying. (K-4018-12)

Further testing involves trials with processors like J.R. Simplot Co. in Caldwell, Idaho, and Carnation Processed Potato Division in Moses Lake, Washington. Simplot is one of the nation's largest potato processing companies.

KEITH WELLER



Gemchip (left), Ranger Russet (top), and Frontier Russet have been released within the past 2 years. (K-4016-5)

Glenn Vogt, manager of agricultural services at Simplot, praises Ranger Russet for its high solids content and good size, top priorities for french-fry processors.

When a potato is high in solids, or dry matter, it won't soak up as much oil during frying as lower-solids potatoes. That's a bonus for both processors and consumers, since oil is costly and adds calories.

Too much oil makes for a flaccid fry. "When you pick up a french fry, it shouldn't droop," asserts potato-expert Pavek.

One drawback to Ranger, which was just released this spring, is its susceptibility to blackspot bruising—grey or black spots found just under the skin.

But future breeding work, using potatoes that resist bruising, could remedy that problem for tomorrow's new varieties. Potatoes with higher protein levels, Corsini found, don't bruise as readily, so he hopes to boost protein content through genetic engineering of existing varieties.

Early Harvest a Plus

Frontier, which was made available to growers in April 1990, matures earlier than Russet Burbank. That's good for growers, who get higher prices for early-season spuds.

Curtis Stoddard, a farmer near Grace, Idaho, says he harvests his Frontier Russets starting in mid-August, about a month before the Burbanks. "We can dig early and finish while the weather's still good," he says. Stoddard's family grew 200 acres of Frontiers last year on their southern Idaho farm.

Although Frontier makes good fries if processed shortly after harvest, it doesn't fry out of storage as well as Russet Burbank. About 80 percent of each year's crop goes into storage, some of it for up to 11 months.

But Frontier could capture a large share of the fresh market, he speculates, because of its smooth skin and attractive appearance.

Many fresh-market potatoes will end up in potato salads, soups, and pancakes, or they simply might be baked. While baked potatoes are often topped with a dollop of sour cream or a pat of butter before they're eaten, not so for those served to volunteer tasters who judge unadulterated spuds on their sensory appeal. They rate flavor, texture, and appearance—deeming the vegetables mealy or watery, sweet or earthy tasting, white, gray, or greenish looking.

The ideal baked potato has white flesh and fluffs easily with a fork, says Mary Lou Ruby, one of the extension home economists who heads the taste tests in Blackfoot, Idaho. Ruby serves each of the dozen or so tasters two potato halves. One half, usually a Russet Burbank, serves as a reference for comparison. The testers—who can't drink coffee or smoke an hour before the test—then grade the potatoes on a scale of one to nine. Frontier and Ranger got high marks—usually sixes and sevens—on par with Russet Burbanks.

What makes a good chipping potato? One with high solids and a very low sugar content, like Gemchip, because hot oil can turn chips brown if sugar content is high.

In western regional trials, Gemchip, which was released in 1989, gave 30 percent higher yields from the field than Norchip, the industry's main chipping potato. Gemchip was initially selected at Presque Isle, Maine, by R.V. Akeley, an ARS researcher, and C.E. Cunningham, of the Campbell Institute for Agricultural Research, and later field-tested in Washington and then by the Aberdeen group.

The new chipper could be a boon to the snack food industry, since Americans eat more than a billion pounds of potato chips each year, according to the National Snack Food Association. Besides their demands for high-solids, low-sugar potatoes, processors also want them large and well-formed so less goes to waste when they're sliced or chipped. But the farmer faces challenges way before potatoes ever get that far—while they're still in the field.

Verticillium wilt is one of the major potato diseases facing growers in warm, arid regions of the western United States. The soilborne fungus contributes to early dying, which cuts yields, says Corsini. Both Frontier and Ranger are less susceptible to *Verticillium* wilt than older varieties.

At the ARS Vegetable and Forage Crop Production Research Unit in Prosser, Washington, geneticist Mark W. Martin has been developing potato varieties with strong resistance to *Verticillium* wilt and other fungal diseases, like early blight and powdery mildew, as well as two viruses—serious problems faced by potato growers.

Martin collects potato germplasm from home and abroad for his breeding projects. Top contenders come from Argentina, Germany, Great Britain, Poland, and Peru's International Potato Center in Lima.

Some of these potatoes are a far cry from our commercial varieties. "When we grow them, we're amazed at how ugly they look—some are lumpy, others are the size of chicken eggs, and many have yellow flesh," says Martin, who has been breeding potatoes at the Prosser station for over 14 years.

From an original population of about 1 million plants, he has identified 40 lines that grow successfully without insecticides, fungicides, or soil fumigants. And that's using virus-infected seed in fields with rampant soil and virus diseases.

In contrast, "if you grow Russet Burbanks or any of our western commercial varieties in such a field, using infected seed, not a single potato will be marketable," says Martin. "Of course, we don't advise farmers to use infected seed; this technique is exclusively used as a research tool."

These clones could reduce risks and costs for growers, he says. That's especially crucial because western potatoes often grow on sandy soil under irrigation—ideal conditions for excess chemicals to seep toward groundwater. To protect their valuable crops, farmers sometimes apply high levels of insecticides, fungicides, and fumigants.

Several of the new multi-resistant lines also look promising in terms of other criteria such as yield, type, solids, storability, handling, and cookability, adds Martin.

FRED WARD

Colorado potato beetle. (K-1291-2)

Ever cut into a potato that looked perfectly fine only to see dark brown veins running through the white flesh? The problem, known as net necrosis, is caused by a virus that is carried to potato fields by tiny, flying aphids.

Their wingless progeny crawl from plant to plant, spreading virus within the field as they probe potato plants with their stylets. "The stylet is like a soda straw the aphid sticks into the leaves or stems to suck out sap," says Peter Thomas, a pathologist who specializes in potato viruses.

In the process, the bugs—who may pick up the virus from weeds or other plants—infect potatoes they feed on, with devastating results.

Viruses are a very serious problem for western potato growers. Farmers in Idaho, Washington, and Oregon spend about $112 million each year to control them, especially potato viruses X and Y and leaf roll virus.

Not all potatoes infected with leaf roll develop net necrosis. But those that do will produce dark, discolored french fries, and major fry producers won't accept the unsightly potatoes. Russet Burbank is particularly susceptible to both the virus and net necrosis, says Thomas, who works at the Prosser research station with Martin.

"When I first began working here, in the mid-70's, 38 percent of the potatoes harvested had potato leaf roll virus," says Thomas. By the 80's, the rate was down to 1 percent.

Improved techniques to detect the virus, developed by Thomas and his colleagues, helped bring about the reduction. The screening techniques are now used by seed-certification agencies, which provide virus-free seed to growers.

The widespread use of aldicarb, a powerful, soil-applied, systemic insecticide that kills the aphid vectors of potato viruses, also helped reduce the rate.

But public concern about groundwater contamination with aldicarb and the potential for aldicarb residues in potatoes led manufacturers to withdraw the product from the market. That lends an even greater urgency to finding nonchemical means to stop the virus.

One option is giving potato plants a way to fight off infection—through genetic engineering. The advantage to such an approach, says Thomas, is that the new, added gene only changes one characteristic and leaves the other characteristics intact. That's not possible with conventional breeding because every cross results in new and different offspring that may be close, but not exactly the same, as the parent.

Scientists can add new genes to many broadleaf plants like potatoes, tomatoes, and tobacco with help from the commonly used vector *Agrobacterium tumefasciens*. The bacterium contains a plasmid, a tiny piece of DNA, that enters a plant's chromosomes during the infection process. Because the DNA actually becomes integrated into the plant's DNA, it's a perfect carrier for introducing foreign genes into plants. *A. tumefasciens* itself has been genetically altered so it doesn't cause the typical

infection signs—galls, or swellings, in the plant's leaves or stems.

The desired gene in this case is one that gives the potato the ability to resist viral infections.

Thomas is collaborating with Monsanto Co. scientists, led by molecular biologist Nilgun Tumer, in field evaluations of Russet Burbank potatoes that contain the viral coat protein gene of potato viruses X and Y.

Last year's results were promising, says Thomas. One Russet Burbank line containing the two genes was highly resistant to both viruses. Tubers from those plants will be planted this spring to confirm their resistance.

The scientists will also field-test 200 lines of Russet Burbanks containing a gene for the coat protein of potato leaf roll virus this year.

Potatoes may harbor not only the troublesome viruses but also a problematic worm, the Columbia root knot nematode. Female nematodes burrow into potatoes and lay their eggs under

KEITH WELLER

Plant geneticist Joseph Pavek (right) and technician Feliks Pazdan examine a new hybrid family of potatoes to be tested in the field this spring. (K-4019-14)

KEITH WELLER

Potato flowers (K-4021-1)

Preserving Potato Plant Diversity

Wild potatoes are found from Nebraska to southern Chile, but plant explorers find most of the diversity growing in the Andean region of Peru, Ecuador, Bolivia, and Argentina. Potatoes were cultivated there perhaps as early as 10,000 years ago.

Now, thanks to ongoing exploration by ARS taxonomist David M. Spooner, a major germplasm collection continues to expand at Sturgeon Bay, Wisconsin. This gene pool of wild and cultivated potatoes promises to improve the crop wherever it is grown.

Begun in 1948, the Inter-Regional Potato Introduction Project (IR-1) is supported by all 50 states, the Agricultural Research Service, and the University of Wisconsin. IR-1 is located on 120 acres at the University of Wisconsin Peninsular Agricultural Research Station near Sturgeon Bay.

The project helps bring new potato plants, seeds, and tubers into the country by way of the USDA Plant Quarantine Facility, Glenn Dale, Maryland. Once potatoes arrive at Sturgeon Bay, researchers preserve, classify, evaluate, and distribute germplasm to breeders worldwide, says ARS geneticist John B. Bamberg, project leader.

IR-1 also exchanges stocks, information, and techniques with the International Potato Center in Lima, Peru, the Braunschweig Genetic Resources Center in Braunschweig (Brunswick), Germany, and other potato germplasm centers.

Some 600 clonal stocks and the botanical seeds of more than 4,000 strains of cultivated potato species and their wild relatives are represented in the collection. Included are about 120 of the 250 tuber-bearing species that scientists have identified.

"Potatoes have more wild relatives than any other major crop," says Bamberg. "We're trying to find the best ways to tap these resources and broaden the genetic base of cultivated potatoes."

A broad base is essential for breeding programs aimed at developing potatoes with disease and insect resistance, higher yields, and better nutritional content.

The next step is incorporating such valuable traits from the raw germplasm into parents that can be used for cultivar breeding. This work is being performed at IR-1 by ARS research geneticist Robert E. Hanneman, Jr.—By **Ben Hardin,** ARS.

the skin. These show up as black spots when potatoes are peeled.

Controlling the nematodes with fumigants costs growers between $200 and $400 per acre and may be an environmental risk.

Certain wild varieties of Mexican potatoes, however, possess strong resistance to nematodes. Charles R. Brown, also a geneticist at Prosser, crossed one of these strains with a cultivated potato. The hybrids are long, russetted tubers that can fend off both races of nematodes found in the Northwest.

Other wild species are so genetically different that they can't be crossed with cultivated potatoes, so Brown and colleague Sandra Austin-Phillips, at the University of Wisconsin, are using protoplast fusion to make hybrids of the two.

KEITH WELLER

Plant pathologist Dennis Corsini compares ARS-developed storage-rot-resistant potato in his right hand with a normal susceptible variety. (K-4017-13)

Potatoes for Tomorrow

Potatoes of the future may boast new genes that enable them to fend off attack by disease, withstand harvest-time bruising, or go untouched by herbicides that fell neighboring weeds. And because biotechnology allows scientists to borrow genes from other organisms, this decade's potatoes for your dinner table may boast genes from a moth, or perhaps from a chicken egg.

Small, laboratory-reared potatoes called microtubers may ease the transfer of prized genes into tomorrow's potatoes. In the laboratory, scientists slice microtubers into thin disks, then coat them with a harmless bacterium that contains new genes. Some of the shoots that later emerge have the new genes actively working and will form healthy plants, says William R. Belknap. He is a plant physiologist with the ARS Process Biotechnology Research Unit at Albany, California.

Last year, potato plants that were genetically engineered in Belknap's laboratory faced their first outdoor test, in Aberdeen, Idaho. Many plants produced tubers of market-quality size and appearance, according to ARS' Dennis L. Corsini and Joseph J. Pavek. They directed the planting, harvesting, and analysis of the potatoes.

The tests in the Idaho potato field employed only marker genes, that is, genes that don't confer useful agricultural traits but do indicate whether plants have taken up and are using new genetic material. This year, however, the Albany lab is producing thousands of experimental seed potatoes that contain one of six potentially useful genes.

With approval from USDA's Animal and Plant Health Inspection Service, colleagues in four states will conduct outdoor experiments of the transgenic potatoes.

For one test, Belknap modified a gene taken from the greater wax moth, a grayish brown pest that feeds on honeycomb. The moth's gene may protect potatoes from blackspot bruising—harvest-time damage that blackens potatoes beneath their skin.

How could a moth's gene help a potato? The enzyme that makes the black color of a potato's bruise uses

In the laboratory, scientists strip walls off cells of the two parent potato lines and place them together in a petri dish. This allows the cells to fuse together and recombine into one cell. The cell then divides repeatedly and grows into a clump of cells called a callus.

The callus sprouts a tiny plant that can later be transplanted to the field.

Austin-Phillips has already produced a potato plant by protoplast fusion that can be used in breeding nematode resistance.

Brown has produced genetically engineered potatoes that contain a gene from *Bacillus thuringiensis* (Bt). Bt is a naturally occurring soil organism that is toxic to Colorado potato beetles. The peanut-sized, yellow-and-brown striped beetles march over the plant's leafy canopy, leaving scraggly, chewed leaves in their wake.

When a beetle larva consumes the Bt, the protein disrupts its gut, causing it to slowly starve to death. Used by organic farmers and others for insect control, Bt is harmless to bees, other beneficial insects, animals, and people, says Brown. Various strains of Bt are already sprayed on a variety of crops and trees to control beetles and caterpillar pests.

"Getting the plant to make its own Bt toxin would save growers time and money," says Brown. "They wouldn't have to continually apply insecticides."

Brown's collaborators at the University of Washington—Helen R. Whitely, Gene W. Nester, and Douglas Bradley—cloned the Bt genes used in the experiments.

Potatoes grown in last summer's field trial contained the gene but didn't produce enough beetle-killing toxin to ward off attacks. Next year's experiments will test plants with a pumped-up version of a new gene that has beetle-battling powers but has never been tried before in plants.—By **Julie Corliss**, ARS.

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an amino acid called tyrosine. The greater wax moth has a protein that stores large amounts of tyrosine. The protein is the product of a moth gene; when inserted into a potato, the gene might change tyrosine's location and form within tuber cells. That might make tyrosine less accessible to the blackening enzyme.

Perhaps most intriguing of the genes targeted for this summer's experiments is one cloned from chicken eggs. An antibacterial gene, it protects vulnerable embryos until chicks develop their own immune system. Researchers are hoping the gene will similarly defend potatoes from two major diseases caused by bacteria—soft rot and ring rot.—By **Marcia Wood,** ARS.

JACK DYKINGA

In Albany, California, ARS microbiologist David Rockhold harvests genetically engineered potato tubers for field trials to be conducted in Aberdeen, Idaho. (K-4009-18)

KEITH WELLER

Computer Model Helps Ensure Clean Water

Farm families and city dwellers alike are increasingly concerned that agricultural chemicals may be contaminating ground water in both rural and urban areas.

About 50 percent of the total U.S. population relies on underground sources for drinking water. In rural areas, groundwater furnishes up to 90 percent of the supply.

"Groundwater contamination is a serious problem that has to be faced by everyone—farmers; urbanites; agricultural leaders; federal, state, and local governments; and agribusinesses.

Unfortunately, there is no band-aid that can be applied to this problem. Above all," says ARS soil scientist Marvin J. Shaffer, "everyone should be aware that contamination of groundwater by nitrates and other chemicals is essentially irreversible. That makes its prevention critical. We must keep contaminants from reaching groundwater supplies in the first place."

It's an awesome responsibility that should not rest entirely with an individual farmer or homeowner—and help is at hand.

In the past, farmers have fertilized to achieve high-yield goals and have paid less attention to nitrate leaching. A real possibility also exists that fertilizers used on lawns, gardens, and golf courses in urban areas may leach into groundwater supplies. Both rural and urban sources threaten groundwater contamination and require site-specific evaluation.

Nitrogen in the form of nitrate is often a contaminant in groundwater supplies. The process of carrying nitrate away from the root zone and closer to groundwater is known as leaching.

Unpolluted streams, lakes, and groundwater will be easier to maintain with the NLEAP computer model developed by ARS and Michigan State University scientists. (K-4013-11)

The season of heaviest leaching is variable throughout the country, and it's important for farmers to know when this occurs. Certainly, they want to avoid a buildup of excess nitrate in the soil profile just before the time of high leaching potential.

"If we can keep plant nutrients in their place—in the root zone where they have the most benefit—both city and farm populations will benefit," says Shaffer.

That's where help from a computer program called NLEAP comes into play. It's a screening package designed to help individual farmers, Soil Conservation Service personnel, farm advisers, and homeowners determine if they have a potential nitrate leaching problem on an individual farm or site.

NLEAP stands for Nitrate Leaching and Economic Analysis Package. The computer model was developed by Shaffer with the assistance of ARS soil scientist Ardell D. Halvorson and Michigan State University associate professor of soil science Francis J. Pierce.

The model, which is designed for personal computers, builds several types of information indexes to predict potential leaching of nitrate nitrogen and its impact on underlying aquifers.

Still in the testing phase, the model has been field-tested at sites in Iowa, Michigan, Minnesota, Nebraska, Ohio, Illinois, and Colorado. So far, the results indicate that the model can accurately identify potential nitrate leaching problems. Eventually, the model will be tested on at least 50 sites throughout the United States.

Included with the model is a national database that provides information on various soils and climates. Information in the database can be pulled up by the computer for any individual state. The information is organized on four diskettes that cover four geographical regions—western, upper midwestern, southern, and northeastern.

The program evaluates the underlying aquifer and ranks it according to its vulnerability to contamination from nitrates. Other, similar programs don't link the nitrate leaching to an aquifer vulnerability index, according to Shaffer.

Today, users of agricultural chemicals can call on the collective knowledge of experts and decision support systems like NLEAP. With this collective knowledge, they can decide on management alternatives, such as timing and rate of nitrogen application, tillage methods, irrigation, use of manures and other organic sources of nitrogen, and crop rotations.

The data used in NLEAP is specific for individual crops, soil types, local rainfall and weather conditions, and practices like irrigation. Making use of this local data, NLEAP users can predict which combinations of conditions could result in groundwater contamination and nip the problem in the bud.

For example, a farmer growing corn each year on a sandy soil can tell if there is a nitrate leaching problem. NLEAP suggests options to the farmer on how to modify rates of fertilizer application, to reduce or redistribute irrigation water, or to grow a legume (such as alfalfa or soybeans) after corn.

Shaffer's work and other ARS projects are one part of the President's Water Quality Initiative, which is a long-term program of federal and state research. The initiative's planning adviser, C. Richard Amerman, who is with ARS, says, "nitrate in the form of nitrogen fertilizer is the main contaminant of groundwater."

The project coordinator, soil scientist Ronald F. Follett, is editing a book entitled "Managing Nitrogen for Groundwater Quality and Farm Profitability."

KEITH WELLER

University of Michigan soil scientist Fran Pierce (left), and Marvin Shaffer review soils data from Ingham County, Michigan, for inclusion in the Nitrate Leaching and Economic Analysis Package. (K-4012-6)

Chapters and appendixes explaining NLEAP and its use and the computer diskettes containing NLEAP are included in the book. Other chapters provide state-of-the-art concepts to minimize potential hazards of nitrate leaching. These concepts were the basis for the NLEAP model.

A related geographical information system project intended to supplement the NLEAP activity is underway that is using geographical information system technology to expand site data. This can be used for developing management plans for farms, watersheds, or entire regions.

The model is adaptable enough to be used by other federal, state, and local agencies, or by farm consultants and state extension personnel. USDA's Soil Conservation Service considers the NLEAP model one of its major tools.

In developing the model, Shaffer and co-researchers have worked closely with state and local agencies, the U.S. Environmental Protection Agency, the U.S. Geological Survey, the National Oceanic and Atmospheric Administration, and the Tennessee Valley Authority.

USDA's budget for all water-quality activities in fiscal year 1990 was $156.6 million, compared with $109.6 million in fiscal year 1989. The budget for fiscal year 1991 is $201.6 million, according to Amerman.

"Information gained from this research will help farmers comply with their state's pollution management programs authorized by the federal Clean Water Act of 1987," says Amerman.—By **Linda Cooke,** ARS.

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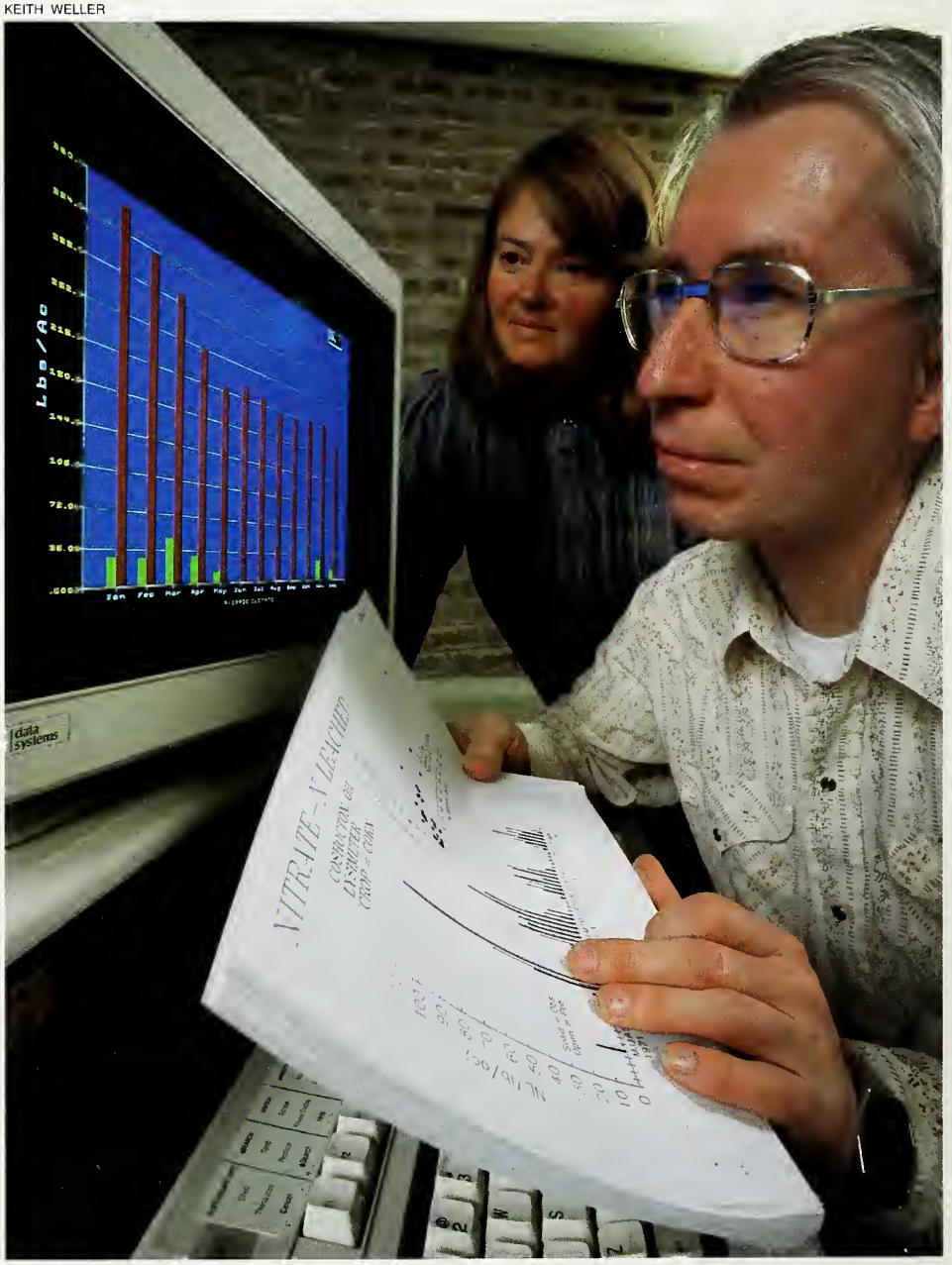
KEITH WELLER



At ARS' Crops Research Laboratory in Fort Collins, Colorado, soil scientists Marvin Shaffer and Mary Brodahl evaluate NLEAP-predicted nitrate leaching for a test plot located near Coshocton, Ohio. (K-4011-14)

Scent of Jasmine Leads to New Business

When ARS rice breeder Charles N. Bollich worked out how to grow Jasmine 85 rice under Texas conditions, he didn't realize the information would give rise to a new industry next door to his lab in Beaumont.

Jasmine 85 rice is the first domestically growable rice similar to the aromatic rices of Thailand, India, and Pakistan. It has the flavor, aroma, and softer consistency that many Asians prefer in rice.

The aroma carries the spicy scent of jasmine as the long-grain rice cooks, although the taste difference is more subtle. Jasmine 85 has been rated as high or higher in aroma, taste, and texture than imported Thai jasmine rice, which fetches premium prices in the United States.

The new variety, developed in the Philippines, was evaluated by Bollich to determine how well it would grow in this country. It was made available to growers as foundation seed in 1989 through the Texas Rice Improvement Association.

Bill Dishman, Jr., a Beaumont rice grower, and Mike Doguet, a rice mill owner, saw the possibility of a new specialty market in Jasmine 85.

"This was the first really new consumer rice product to come along in a long while," Dishman says.

A fourth-generation rice farmer whose land borders the ARS Rice Research Laboratory, Dishman was willing to commit to growing the jasmine rice. Doguet revamped his mill to handle the new rice, which requires special polishing equipment.

In April, the Doguet-Dishman Rice Company was formally unveilled.

"Since we opened for sales, we've hardly been able to keep up with the growing demand," Dishman says. "Although we've been concentrating on the Gulf Coast region, we've had calls from all over the country and even up into Canada."

This year, the company harvested 2,200 acres of Jasmine 85 for about 13 million pounds of rice. They expect to put in even more next season by contracting with growers.

Jasmine 85 has been a very high-yielding rice for Dishman, outproducing every other regular variety he's planted.

Jasmine 85 has been rated as high or higher in aroma, taste, and texture than imported Thai jasmine rice, which fetches premium prices in the United States.

"But there are a lot of growing characteristics we're still learning about," Dishman says. "Charlie Bollich has worked with us from day 1. We could never have started growing this rice without his work."

Jasmine 85 has also required "quite a bit less fertilizer" and at least this past year has shown resistance to some of the fungi that often attack rice, eliminating the need for fungicides.

"This may not be true every year—only time will tell how often we'll be able to get by without applying fungicides," Dishman says. "But every time we do, it's a real savings."

Because Jasmine 85 is also a late-maturing rice, growing it on part of the farm allows Dishman to spread out his harvesting, which puts less stress on people and equipment.

"On one hand, the late maturity increases our exposure to damage by hurricanes; on the other, it is worthwhile to have a larger window for harvesting," Dishman said.

The company has concentrated on two different markets for the new product: as a staple for the Asian ethnic population in the United States who seek a less expensive alternate to imported aromatic rice, and as an upscale specialty item.

For the gourmet market, they produce a 2-pound package labeled in bright yellow and red. For the ethnic market, their product is a 25-pound sack, which they are printing in five different languages—Vietnamese, Chinese, Thai, Cambodian, and English.

Dishman believes specialty market rices like Jasmine 85 can help stabilize their revenues. "Specialty rices should not show the price fluctuations that affect ordinary rice," he explains. "And they can help replace the rice that was grown to sell to Iraq."

And, as the market for the aromatic increases, the company will grow and they expect new jobs to be created.—By **J. Kim Kaplan,** ARS.

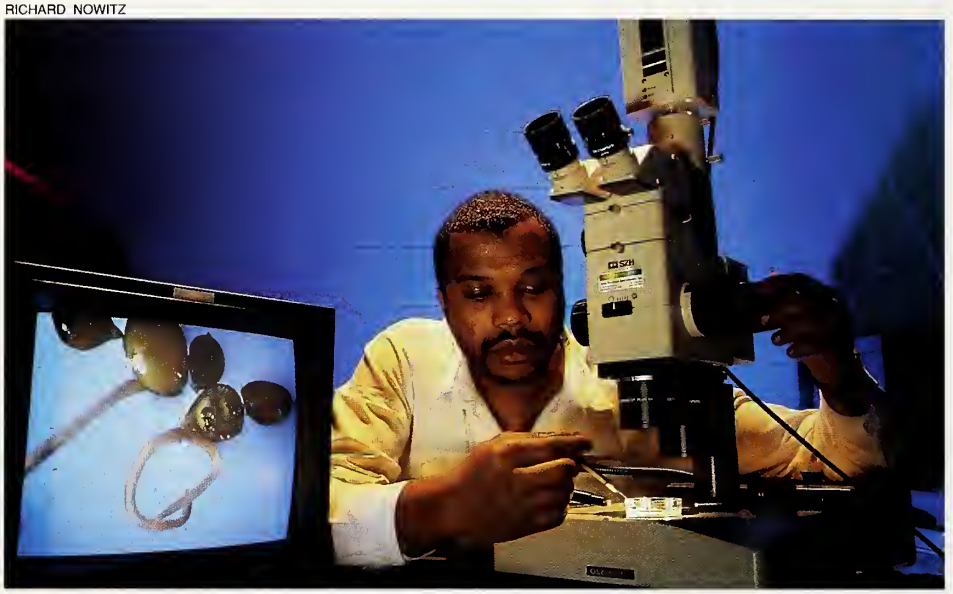
Charles N. Bollich (retired) was at the USDA-ARS Rice Research Laboratory, Imes Rd., Beaumont, TX 77713. Phone: (409) 752-2741 ◆

KEITH WELLER

(K-4024-1)

Do Earthworms Affect Groundwater?

RICHARD NOWITZ



At the Soil Tilth Research lab in Ames, Iowa, technician Ken Ford uses a video camera adapted for microscopic work to study earthworm cocoons (top of monitor) and newly hatched earthworm larvae. (K-4024-1)

Earthworms, nature's master tillers, can enhance plant growth by making soil porous so it drains and aerates well.

But do the underground channels they create speed downward movement of agricultural chemicals? If the answer is no, at least for some worm species, what should be done to foster their good works?

The North Appalachian Experimental Watershed at Coshocton, Ohio has been the scene of possibly the longest no-till experiment in the country: 27 years and still going strong.

No-till—that is, planting crops without first plowing to clear and bury the residue of the previous crop—was designed to reduce surface runoff of soil and agricultural chemicals in water that flows into lakes and streams—not specifically to preserve groundwater quality, says William M. Edwards, leader of conservation tillage research at Coshocton.

The absence of plowing and the abundant crop residue left on the surface does create a favorable environment for many earthworms, he says. But he's not convinced earthworms play more than a very small role in the transport of chemicals to groundwater.

Edwards did find that vertical burrows can provide flow paths to carry nitrate and other agricultural chemicals down into the soil. But just because the chemicals may go down a few feet doesn't mean they will end up in groundwater, he says.

To further put the problem in perspective, he notes that in one summer less than 4 percent of rainwater that infiltrated soil at a Coshocton site went into burrows of nightcrawlers (*Lumbricus terrestris*).

Nightcrawlers, usually 4 to 8 inches long and about 3/8 inch thick, feed on crop residues near the soil surface mostly at night. They build permanent burrows to the surface that go down as far as necessary to escape winter cold and daytime summer heat—in Ohio, perhaps 3 feet or more.

Seven other earthworm species at Coshocton were identified by ARS entomologist Edwin C. Berry of the National Soil Tilth Laboratory, Ames, Iowa. Adults of these species were usually 2 to 6 inches long and half the diameter or less of nightcrawlers.

Most of their activity is in the first foot of topsoil as they make temporary burrows, passing soil containing organic matter—all the food they need—through their bodies.

Small horizontal burrows may help water to soak into the soil to be used by plants without moving it anywhere near the groundwater, says Edwards. Increased infiltration also means less surface runoff is available to carry fertilizers and pesticides to lakes and streams.

Moreover, the burrows provide soil aeration to accelerate microbial action, speeding the breakdown of pesticides.

In the last couple of years, Edwards has turned most of his attention to pesticide movement. For his studies, he brings cubic-foot blocks of no-till cornfield topsoil into the lab and exposes them to artificial rainstorms of various intensities. During and after each rainstorm, water drains through the soil and is collected in 64 funnels below each block.

Edwards found the amount of atrazine and alachlor herbicides collected in funnels below nightcrawler burrows depended greatly on the sequence of rainstorms. If the initial rainstorm was minor, it carried the herbicides just far enough down to mix with and bind to organic matter. Very little moved downward if a major rain then followed. But if a major storm came first, more of the herbicides moved downward.

Although ARS studies in Coshocton, have come up with some answers, what applies in Coshocton doesn't necessarily apply elsewhere.

In an ARS study at St. Paul, soil scientist Dennis R. Linden and his colleagues also saw relationships between organic matter from crop

residues, earthworms, water infiltration, and chemical movement in the soil.

Soil from no-till plots where the researchers had removed cornstalks for 5 years supported only inconsequential earthworm populations. But plots where residues were left on the surface or where residues were incorporated into the soil by tillage supported active populations of common field worms. With increased burrowing, more water infiltrated the soil, says Linden.

Mixing cornstalks into the soil resulted in more infiltration, but the burrows were less continuous with the soil below, resulting in less chemical movement deep into the soil.

In further studies, the St. Paul scientists grew corn in several ways: in soil with no crop residue; with incorporated residue or surface residue, and with or without a common earthworm—*Lumbricus rubellus*—that lives near the soil surface. Then, to see how the earthworms might affect the movement of pesticides through the soil, the scientists applied potassium bromide to the soil surface and slowly applied simulated rainfall.

"We found surface residue provided a major food source for worms, helping them to form stable burrows that were open to the surface," Linden said. These burrows allowed rapid water infiltration, but 95 percent of the bromide was retained in the top 6 inches of soil. In soil with incorporated residue, that same amount of bromide went down 5.3 inches as more of the water was soaked up near the soil surface.

In a 1988 springtime survey of earthworms in Minnesota soils, Dennis J. Fuchs, then a graduate research assistant, and Linden found the rate at which water was conducted through the top foot of soil increased in proportion to the earthworm population.

The common field worm, *Aporrectodea tuberculata,* was the most populous earthworm species in the survey. Five other, less abundant species also stayed mostly in the upper foot of soil. The scientists also found:

- Alfalfa and forage grasses supported the highest earthworm populations (up to 830 per cubic meter of soil).
- Medium-textured soil types that were neither extremely acidic nor alkaline supported high populations; coarse-textured soils supported almost no earthworms.

In an ongoing 5-year study at the National Soil Tilth Laboratory, scientists are studying the effect of various life forms, including several earthworm species, on movement of plant nutrients and pesticides toward groundwater. During each season, the researchers measure distributions of roots, microbes, earthworms, and insects in several Iowa soils with differing tillage and residue management regimes.

"We plan to use these measurements to begin developing computer models that will help us predict pesticide breakdown, groundwater quality, and changes in soil tilth," says Jerry L. Hatfield, laboratory director.—By **Ben Hardin** and **Don Comis,** ARS.

William M. Edwards is at the USDA-ARS North Appalachian Experimental Watershed Research Unit, P.O. Box 478, Coshocton, OH 43812. Phone: (614) 545-6349. Dennis R. Linden is at the USDA-ARS Soil and Water Management Research Unit, 454 Borlaug Hall, University of Minnesota, St. Paul, MN 55108. Phone: (612) 625-6798. Jerry L. Hatfield and Edwin C. Berry are at the USDA-ARS Soil Tilth Research Laboratory, 2150 Pammel Drive, Ames, IA 50011. Phone: (515) 294-5723. ◆

Irrigation Versus the Earthworm

When earthworms wriggle towards water flowing through an irrigation furrow, their tiny tunnels drain water down and away from the trench. That leaves part of the field high and dry, says Thomas J. Trout, an agricultural engineer at the Soil and Water Management Research Unit in Kimberly, Idaho.

To make up for the wormhole losses, farmers must increase furrow flows to move water across the field, which can increase erosion.

Trout studied this problem on 35 fields planted with beans, corn, sugar beets, or alfalfa in south-central Idaho.

Water infiltration rates were increased up to 20 percent in a third of the irrigations because of worm-pierced furrows.

Trout found that farmers can fend off earthworms by adding low concentrations of aqueous ammonia to their irrigation water.

However, unless the problem is severe, farmers probably won't want to spend money on ammonia, which would cost about $15 per acre. Other options include switching to sprinkler irrigation or practicing minimum-till.—By **Julie Corliss,** ARS.

LOWELL GEORGIA

Earthworms, nature's master tillers, can enhance plant growth by making soil porous so it drains and aerates well. (K-3237-1)

Quest for a Vaccine To Counter CLA

The sheep disease known as caseous lymphadenitis (CLA) shortens lifespans, reduces wool production, and makes carcasses unfit for consumption. The U.S. sheep industry loses about $250,000 annually from carcasses being condemned because of CLA lesions, says Kim A. Brogden, ARS microbiologist at the National Animal Disease Center in Ames, Iowa.

Caused by the bacterium *Corynebacterium pseudotuberculosis*, the disease produces severely enlarged lymph nodes and ugly lesions filled with pus. The bacterium is a small, club-shaped rod that gets its long name from the tuberculoid lesions. The organism may spread to the lungs and other internal organs, inducing large fibrous abscesses.

Milk production in dairy goats infected with CLA is severely reduced. In sheep, the bacterium has been associated with thin ewe syndrome. In addition, infected animals experience much discomfort.

All U.S. sheep and goats are susceptible. Once an animal is infected, the disease persists the entire life of the animal and can slowly infect the entire flock. "And it never gets better," says Brogden.

In Australia, CLA is the leading cause of economic loss to the sheep industry. Here, CLA is the third leading cause for condemnation of sheep carcasses at slaughter, following emaciation and pneumonia.

"Veterinarians the world over would welcome an improved vaccine for this insidious disease. A company selling this type of product could hope to sell 100,000 doses in the first year," says Don E. Bailey, executive secretary of the American Association of Small Ruminant Practitioners. Bailey lives in Roseburg, Oregon, where he keeps a 300-head flock of sheep. He says about 5 percent of them are infected with CLA.

CLA is spread by contact among sheep, and the bacterium can live for months in dust in barns, shearing sheds, and corrals.

RICHARD NOWITZ

Microbiologists Howard Lehmkuhl (standing) and Kim Brogden collect blood from a sheep to test for antibodies against CLA. (K-4030-1)

"Because the bacterium becomes walled off in the enlarged lymph nodes, treatment with antibiotics is useless, which makes it all the more important to protect animals in the first place via vaccination," says Brogden.

Research to develop an effective low-cost vaccine began 6 years ago at the National Animal Disease Center.

Brogden made the first vaccine for CLA from killed whole cells of the bacterium and tested it on naturally infected sheep and goats in field trials done in cooperation with researchers at the University of Guelph, Ontario, Canada.

Veterinarians Paula Menzies and Ann Muckle found the vaccine effective in reducing the number of animals that would develop the disease naturally. Fewer than 6 percent of the vaccinated goats developed abscesses, compared to almost 12 percent of the nonvaccinated goats. In sheep, 6 percent of the vaccinated sheep developed lesions, compared to 34 percent of sheep that were not vaccinated.

Results of this study will be reported in the Canadian Journal of Veterinary Medicine.

The Canadian field trial revealed a serious side effect of giving the first-generation vaccine in a 5-mg dose. Animals receiving it reacted with redness, swelling, and lameness at the vaccination site. Almost 30 percent of the goats and 34 percent of the sheep developed lumps from the vaccination.

To overcome this problem, Brogden lowered the dosage of immunizing material. And to keep the same level of protection, he added an immune booster called muramyl dipeptide.

Muramyl dipeptide was developed by Louis Chedid, M.D., who is with VACSYN in Tampa, Florida. Chedid provided the MDP to Brogden under

KIM BROGDEN

Electron micrograph of *Corynebacterium pseudotuberculosis*, a club-shaped bacterium, the causative agent of CLA.

the provisions of a cooperative research and development agreement between VACSYN and USDA.

So far, the current field studies of the second-generation vaccine are being done in cooperation with researchers at the University of California at Davis. Veterinarians John S. Glenn and Nancy East and sheep specialist Rob Rutherford report no side effects from this vaccination after the first year. The results of this trial will not be ready for another year or two. Animals exposed to the bacterium may not show signs of the disease for almost 2 years.

Brogden says of the lower dose vaccine: "It's economical, nontoxic, and fully potent—important concerns for animal protection products."—By **Linda Cooke,** ARS.

Kim A. Brogden is at the USDA-ARS National Animal Disease Center, P.O. Box 70, Ames, IA 50010. Phone (515) 239-8287. ◆

Lean Bodies Make Texels Desired Lamb

Five years ago in late April, Mike Wallace arrived in New York and went to work loading 20 pregnant ewes on a truck bound for Clay Center, Nebraska, and the ARS U.S. Meat Animal Research Center.

Imported from Finland, the ewes were supposed to give birth after they arrived at the ARS facility. But Wallace recalls that there was a 30-day delay in handling the importation. The experience sticks in his memory because during the 34-hour ride from USDA's New York Animal Import Center in Rock Tavern, New York, he delivered two sets of twins and a single lamb.

Delivering lambs wasn't a new experience for the 12-year veteran sheep operations manager at MARC, but doing it in a moving truck was.

Texels were the first sheep imported from Europe to the United States since Finnsheep were imported in the 1960's. The sale of the Texels marked the first release of germplasm in the United States to sheep producers.

Wallace says he felt a good deal of satisfaction when some of the Texels were sold recently for breeding stock during MARC's annual sheep sale. "A lot of people worked hard to get Texels into this country and to set up the 5-year quarantine program."

The Texels were quarantined since 1985 to ensure they didn't have scrapie—a debilitating brain disease that causes eventual death. Although only a small number of sheep have been diagnosed with scrapie in the United States, its prevention requires strict quarantine procedures for all animals imported from Europe.

Once the Texel ewes, rams, and lambs had their feet down at MARC, ARS animal geneticist Kreg A. Leymaster began an experiment to evaluate the Texels as a potential terminal sire breed.

"All lambs from a terminal sire breed are intended for slaughter," Leymaster says, "so breeders focus on growth rate and carcass leanness.

"The Texels were known for their ability to produce lean, meaty carcasses," says Leymaster. "And we wanted to see how the Texels compared to the Suffolks, a U.S. breed also known for its efficient, lean growth rate.

"Initially, we saw little difference in growth between the Suffolks and the Texels. After 9 weeks of age, Suffolks were producing lean and fat more rapidly than Texels but in a similar ratio. Lambs are usually sold at 115 to 120 pounds—when they are 6 to 9 months old.

The Texels' strength is their ability to achieve low fat content relative to their intermediate growth rate and mature size. Texel and Suffolk carcasses had the same fat content when compared at a common carcass weight.

Preliminary studies indicate that the Texels are competitive with Suffolks. But the Texels had an edge because more Texel lambs survived to weaning. The Texels had 89 percent survival compared to 81 percent for Suffolk lambs. The Texels had a birthrate of 1.8 offspring per mature ewe, which is slightly higher than that of many breeds in the United States.

The MARC studies were undertaken to evaluate the merits of the Texel breed for U.S. sheep production. In addition, the information about U.S. Suffolks is now available for other countries that may consider importing them. "Either way, the U.S. sheep industry should benefit," says Leymaster.—By **Linda Cooke,** ARS.

Mike Wallace and Kreg Leymaster are at the USDA-ARS Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, NE 68933. Phone (402) 762-4172. ◆

Predicting Accidental Bee Kills

Beekeepers can now better handle their beehives by using a computer program to simulate results of their management techniques. Using PC-BEEPOP, a honey bee population computer model, beekeepers can also predict the effects of pesticide kills and natural losses due to disease, adverse weather, and old age.

"Pesticide kills happen at an alarming rate in agricultural areas. The computer model, which provides toxicity information on pesticides, can also simulate the effects of pesticides entering a hive," says Agricultural Research Service entomologist Gloria DeGrandi-Hoffman at Tucson, Arizona.

Beekeepers can learn how to combine two weak hives in the fall to create one stronger hive, a practice that will actually make more money. Usually, bee managers are reluctant to combine two hives because they have to kill one of the two queens.

"As the program demonstrates, replacing older queens with younger ones will often boost honey production even in strong hives," says DeGrandi-Hoffman.

Beekeepers could also enter winter weather information in the computer to estimate populations in the spring. This would allow time to order replacements or scale down business.

Beekeepers, extension agents, and instructors of apiculture, basic biology and entomology now use the program. "It's a great teaching tool, says DeGrandi-Hoffman. "People can learn the consequences of their management decisions and avoid those that hurt their operation."

She wrote the original program, and entomologist Jerry Bromenshenk at the University of Montana in Missoula adapted it for use on IBM-compatible personal computers. A hard disk and color graphics card are required.

The program is available from DeGrandi-Hoffman or Bromenshenk to those who request it and furnish a blank, formatted 5.25-inch 1.2 Mb floppy disk.—By **Dennis Senft,** ARS.

Gloria DeGrandi-Hoffman is at the USDA-ARS Carl Hayden Bee Research Center, 2000 East Allen Road, Tucson, AZ 85719. Phone: (602) 670-6380. ◆

JACK DYKINGA

To prolong color freshness, chemist Harold Bolin treats peeled carrots with a hot water and citric acid bath. (K-4007-10)

Carrot Sticks Can Keep Their Color

Fresh carrots—peeled, sliced into sticks, bagged, and ready for lunch box or relish tray—sometimes develop a white film that masks the crisp veggie's bright orange color.

Now, food processors can rely on a new approach to delay the natural film from forming. And, the technique is simple, fast, and inexpensive says its developer, ARS chemist Harold R. Bolin at Albany, California.

He recommends dipping freshly peeled carrots for 30 seconds in a hot (160°F) water/citric acid solution after they have been through a commercial abrasion peeler.

Citric acid is already approved for food use, Bolin notes, and doesn't change carrots' flavor. The heat won't damage them either if they're immediately dunked in cold water.

Treated carrots are additive free. If refrigerated, they keep their original color up to 10 times longer than untreated, abrasion-peeled carrots.

Bolin started experiments with carrots soon after he learned that a major U.S. processor of fresh fruits and vegetables had essentially given up trying to solve the problem.

Tactics that may keep slices of apples or peaches from turning brown won't stop peeled carrots from making the hazy film. That's because different enzymes are at work.

Fruit browning is mostly the fault of polyphenol oxidase enzymes. Whitening of carrots, however, probably results from enzymes such as phenylalanine ammonia lyase. Heat will stop the enzymes, says Bolin, and acidity makes the enzymes more sensitive to heat; that's why hot water, made acidic by citric acid, does the trick. Carrots make the white film for protection, to replace the outer skin removed by peeling.—By **Marcia Wood,** ARS.

Harold R. Bolin is in USDA-ARS Process Chemistry and Engineering Research, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710. Phone: (415) 559-5863. ◆

Just off press: "Maintaining Insect-free Farm Stored Grain," (AIB-580) a booklet informing farmers of the best ways to protect grain during storage may be purchased from the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Phone (202) 783-3238. Request stock number 001-000-04565-2.

Southern Blueberries Need Honey Bees

Growers of a relatively new and increasingly popular southern highbush blueberry named Sharpblue may want to stay on friendly terms with honey bees.

The southern highbush varieties were developed as early-producing alternatives to the conventional rabbiteye blueberry and are better adapted to the southern climate than are northern highbush cultivars. Sharpblue has become one of the most popular blueberry varieties for new plantings in Florida.

But to get the best early harvest, Sharpblue must be cross-pollinated, according to a joint study by the ARS Honey Bee Breeding, Genetics, and Physiology Laboratory with Louisiana State University in Baton Rouge.

"With cross pollination, Sharpblue growers get bigger fruit that ripens earlier—and early-season blueberries are where the biggest profits are," says ARS entomologist Robert G. Danka, who worked on the project with LSU horticulturist Gregory Lang. "According to our tests, the increase in revenue if you cross-pollinate amounts to about $2,500 per acre—revenue goes from $5,500 to $8,000."

Because the researchers were extrapolating from test plots to commercial orchards, Danka says the $2,500 figure may be a little soft, "but clearly we are talking about a substantial increase."

Commercial growers usually supply bees for pollination by renting hives for their fields in early spring rather than depending on wild honey bee populations.

Cross pollination requires a nearby pollen source from another variety such as Gulfcoast—one of two new southern highbush blueberries released from the ARS Small Fruit Research Station at Poplarville, Mississippi.

While Sharpblue is popular in Florida, the researchers believe Gulfcoast is better adapted to conditions in Louisiana.

Sharpblue is almost too early, Danka says. "It can start flowering before Christmas, and that leaves it vulnerable to cold spells we may have later."

It surprised Danka to find that in Louisiana, Gulfcoast appears to produce just as well with self-pollination as it does with cross pollination.

"These southern highbush varieties are so new that we're still discovering their pollination requirements," Danka says.—by **J. Kim Kaplan,** ARS.

Robert G. Danka is at the ARS Honey Bee Breeding, Genetics, and Physiology Laboratory, 1157 Ben Hur Road, Baton Rouge, LA 70820-5502. Phone: (504) 766-6064. ◆

Wash-Off Data Surprises Pesticide Planners

It's not the intensity, but the volume of rain that counts when it comes to washing pesticides off plants.

The first tenth of an inch of rain removes almost all of the pesticide that is going to wash off, regardless of how long it takes for that amount to fall, according to studies by ARS soil scientist Guye H. Willis.

"It doesn't matter whether it takes a minute or an hour—a heavy storm or a sprinkle—for a tenth of an inch of rain to fall, it's that volume that's the significant factor, not how hard the raindrops hit the leaves," says Willis, who works at the ARS Soil and Water Research Unit in Baton Rouge, Louisiana.

The studies, which were done in cooperation with the Water Quality and Ecology Research Unit at the USDA National Sedimentation Laboratory in Oxford, Mississippi, indicate that organochlorine pesticides are the least susceptible to being washed off by rainfall, while the more water-soluble chemicals are the most susceptible.

For example, 0.1 inch of rain will wash off about 50 percent of a water-soluble pesticide that was on the plant when the rain began, but only about 2 percent of the organochlorine pesticide, which has very limited solubility in water.

Previous studies didn't consider which is the significant factor in pesticide washoff—the amount of rain, the size of raindrops, or the energy with which they fall.

"But with the shift toward short-lived pesticides, their concentration in runoff will become more of a function of the chance of rainfall washoff," Willis says.

Knowing which is the significant factor will allow more precise laboratory and environmental chamber testing of pesticides for runoff possibilities.

"And knowing that the amount of rain is the most important factor will actually simplify things a little," Willis says.

His results have already been used to modify several computer models that track environmental effects, including ARS' model for groundwater loading effects of agricultural management systems (GLEAMS).

The possible direct commercial application of the information is limited because farmers have always tried to avoid applying pesticides just before a rain.

"For farmers, this work just confirms how much impact even a light rain could have on the effectiveness of their pesticides," Willis says.—By **J. Kim Kaplan,** ARS.

Soil Scientist Guye H. Willis is at the USDA-ARS ARS Soil and Water Research Laboratory, Box 25071, Baton Rouge, LA 70894. Phone: (504) 387-2783. ◆

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