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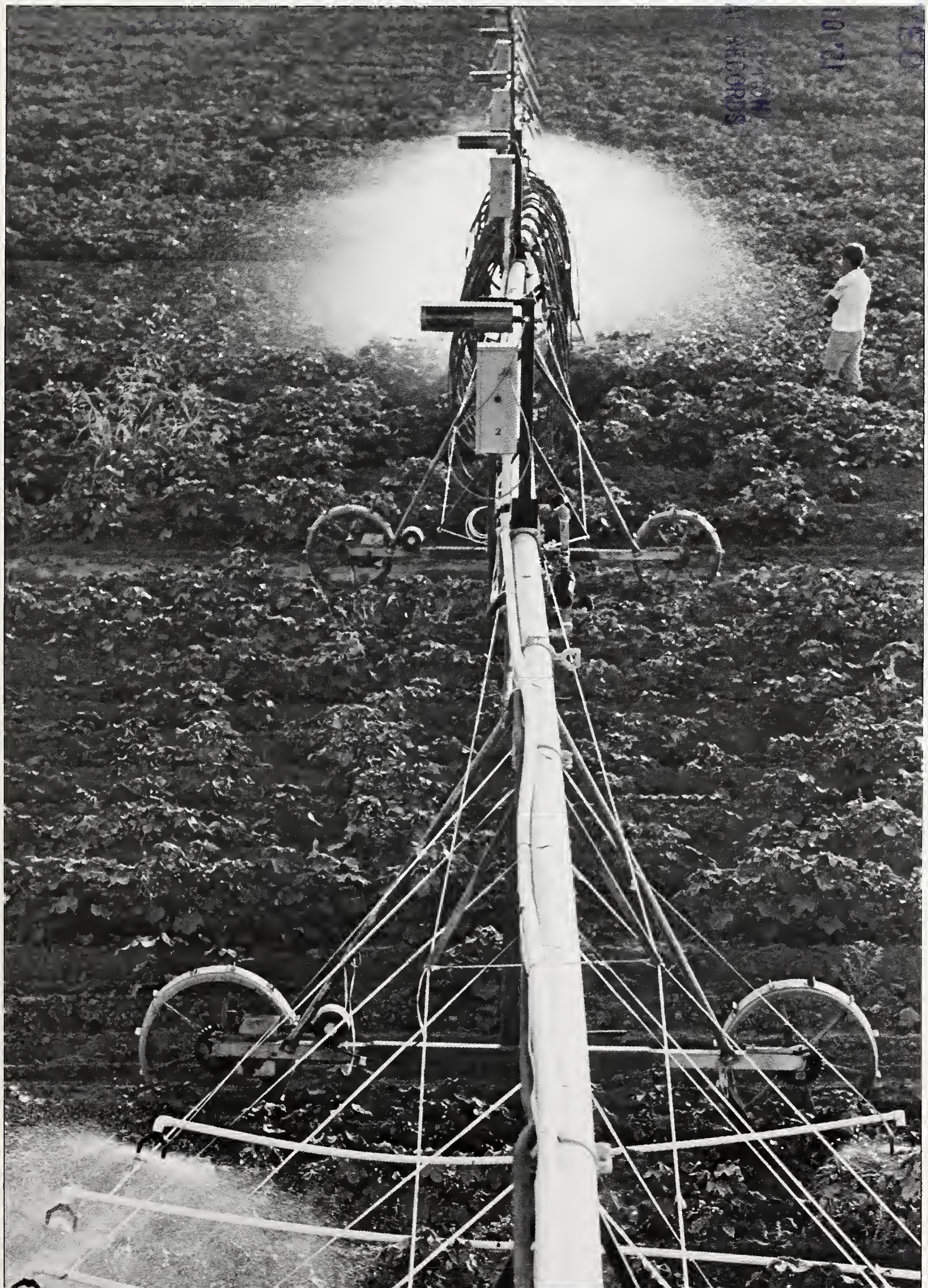
Agricultural Research



Erosion — Our Nation's Most Serious Challenge

Each year the United States loses about 5.5 billion tons of topsoil.

Enough topsoil erodes from the land into the Mississippi River alone in one year to build an island one mile long, a quarter mile wide, and 200 feet high. Each June the waters of the Palouse River in eastern Washington usually carry away about 3 million tons of fertile topsoil from one of the most productive farm areas in America. In less than a century, this region has lost enough topsoil to cover an area eight blocks square eight stories high.

Today soil erosion is our Nation's most serious challenge!

The soil is invaluable to the economic development and prosperity of the United States. Even in the 1930's — the worst of times — this was true. Agriculture — its researchers and farmers — overcame the ravages of the Dust Bowl years and proved that the United States could grow all the food and fiber needed to feed the people of the world. Today, we export the harvest from one out of every three acres planted. Each year, agricultural exports become more important to the country's trade balance.

As the year 2000 approaches, evidence indicates that we could be running out of land for increased food and fiber production. This means we will have to produce more on each acre farmed. If soil losses from erosion remain unchecked, our physical capacity to produce food and fiber at reasonable costs is severely threatened.

However, the future of agricultural productivity in this country — deeply embedded in the soil — is far from hopeless. Recent advances in agricultural science and technology are beginning to supply farmers with new, practical systems for controlling soil erosion and restoring marginal land on America's 2.3 million farms.

Conservation tillage is one of these systems. In conservation tillage, farmers leave the land uplowed while utilizing crop residues to control erosion. Field plot tests by ARS researchers showed in one instance that leaving 3 tons per acre of crop residue atop the field reduced soil erosion loss 85 percent.

Minimum and no-till systems, also forms of conservation tillage, proved effective in combating soil erosion. ARS research findings indicated that in one case where no-till was practiced on soybeans, only 0.13 tons per acre of soil eroded as compared to 12.92 tons from tilled soil.

Last year farmers used no-till and other forms of conservation tillage on 60 million acres of cropland — a significant increase when compared to the 4 million acres that were put into conservation tillage during the last 16 years.

Other research programs continue to be effective — water runoff can be noticeably reduced by new furrow systems; new grasses are being developed to withstand drought and hold soil in place; and other techniques such as improved cropping sequences are being introduced.

Mathematical modeling is another tool in the erosion battle. A team of ARS and state scientists has developed a computer-based model called CREAMS (Chemical, Runoff, and Erosion from Agricultural Management Systems) for reducing soil loss in non-point pollution. Using CREAMS, soil scientists and land planners can analyze a shopping list of causes for erosion and water pollution — from soil type to rainfall and slope of the land.

Progress continues; yet we have a great deal of work ahead — even as agricultural research adopts computers and alternative farming practices to save the soil.

Years of data are needed to evaluate the effects of what is generally a slow process. We notice only the dramatic pictures of erosion, as when, in a raging storm, a sloping field is rutted into gullies. Anyone — city dwellers or farmer — can see the scarred land; perhaps, only the farmer knows what it means: a loss of fertile topsoil, increased farming costs to restore productivity, and hours of hard work. We need to control both what we can and cannot see.

Only then can we meet the challenge of saving our Nation's precious land.

By Henry Becker III, ARS

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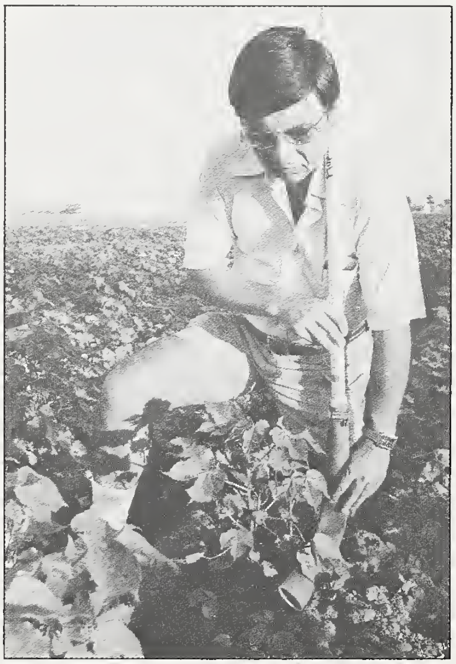
Cover: California cotton fields are the testing grounds for this laser-aligned traveling trickle irrigation system, which links traveling and trickle concepts to improve irrigation efficiency for row crops. Here, wheel towers—operating laterally from a concrete-lined irrigation canal—carry a water line across the field. Mike Sikorski, electrical engineering assistant, observes efficiency of the different water placement control orifices on each tower section (0781X875-33).

Laser Aligns Traveling Trickle Irrigation System

Above: The system's main tower pumps water into the water line as it moves along the canal track. It also guides field towers and keeps them aligned by means of a vertical laser plane. On top of the main tower, Sikorski aligns laser transmitter to create a vertical plane that is perpendicular to the canal (0781X877-26a).



Right: Project leader Claude J. Phené, ARS soil scientist, positions drop line and calibrated test orifice next to plant row for most efficient water delivery (0781X883-10).

A laser-aligned traveling trickle irrigation system being researched on tomato fields at Fresno, Calif., includes several components that may one day be a part of future irrigation systems.

"The use of trickle irrigation concepts applied to a traveling irrigation system could improve the irrigation efficiency of row crops and help solve the economic and labor problems imposed by conventional solid set trickle irrigation systems," says Claude J. Phené, ARS soil scientist.

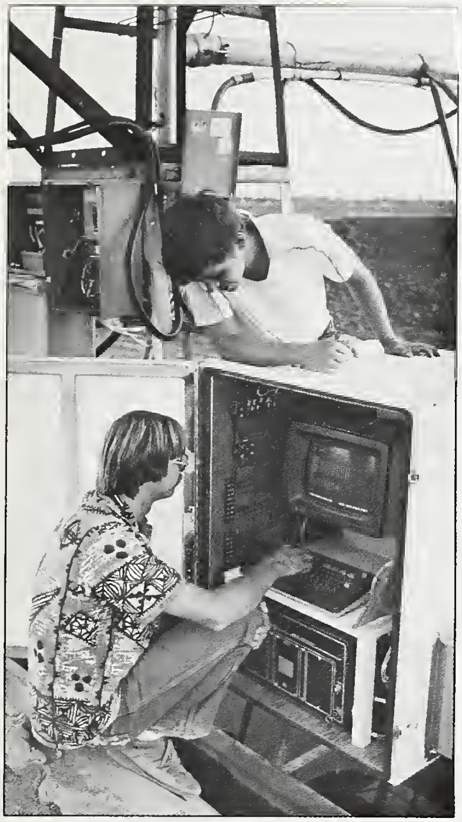
The system consists of a main tower and several wheeled towers operating laterally from a water-filled, concrete-lined irrigation canal. The main tower uses the canal as its track and the field towers are kept in perfect alignment by use of a vertical laser plane emanating from the main tower. Multiple-cell laser receptors on each of the field towers are interfaced to small electric motors that power the field towers. Ports in the receptors sense when a particular tower is too fast or too slow and the speed of the motor is altered to bring the tower back into alignment.

Water is taken from the canal by a pump on the main tower. A water line carried by the field towers meters the water through manifolds to trickle irrigation drop lines that deliver any pre-set amount to within inches of plants. No water is "wasted" between rows.

While only water was applied to the field, the future calls for the towers to carry lines to apply fertilizer, herbicides, and insecticides.

When funds become available, Phené says, the system will be rigged to carry solar panels to charge batteries, making it self contained and self-powered.

When completed and implemented, a computer program will make the system automatic in nearly every respect. The program will include weather and soil information that will take into account solar radiation, air temperature and humidity, wind speeds, soil moisture, evaporation from the soil, and plant transpiration. As soil and weather sensors indicate the need for water, the computer will turn on the system until the crop's water needs are satisfied.



"Eighty-five percent of the total irrigated land in the United States—about 61 million acres—is in the 17 western states. About 15 percent of this total is in California, where 85 percent of the water used is in irrigation. In many instances, this amount of water exceeds the actual evapotranspiration requirement of these crops, and much of that excess is wasted.

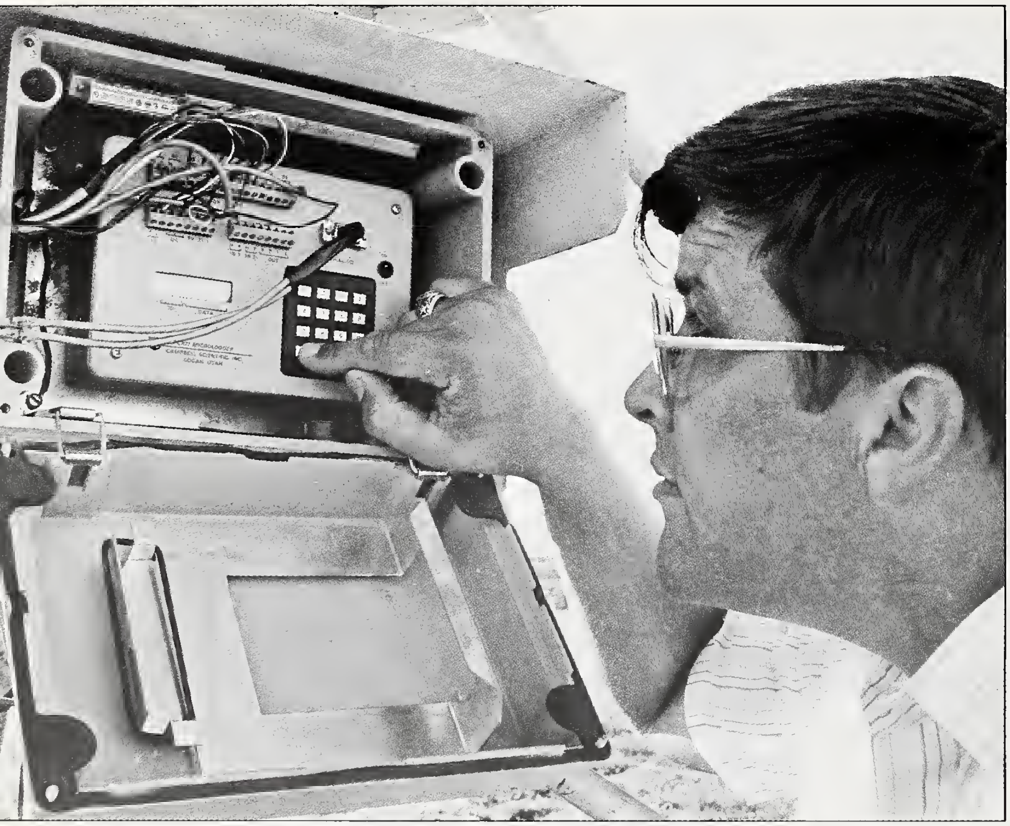
"Gravity irrigation systems—77 percent of California irrigation systems—are used for irrigation crops and are the least water-efficient systems because the soil is used to transport the water over long distances, resulting in uneven distribution," says Phené.

Overirrigation often causes excessive drainage, and the ensuing buildup in the shallow perched water table results in root-zone salinity problems. The water not infiltrated into the soil either stays ponded for several hours or contributes to the runoff. In either case, a great percentage of this water is lost to evaporation.

"Furthermore, excess soil water is detrimental to many crops and to

Top left: Automating the irrigation system almost completely, this main tower computer system controls water allocation, reads water meters, and turns system on and off. Heimann, assisted by Sikorski, checks one of the system's programs (0781X878-23).

Above: Ken Heimann, research assistant, foreground, and Sikorski adjust irrigation drop lines, which deliver water within inches of plants, eliminating waste between rows (0781X881-12).



Above: Terry Howell, agricultural engineer, programs a weather station computer for solar radiation, wind, air temperature, and humidity readout. This system monitors measurements from weather data instruments and delivers them to the main computer. The main computer then processes this information in order to deliver the right amount of water to the field (0781X879-8).

nitrogen-use efficiency because it causes denitrification, volatilization, and leaching—depending on the source of nitrogen used," Phené adds.

"Trickle irrigation of row crops can potentially conserve water, fertilizer, and energy. However, solid set trickle irrigation of large row crop fields has not been attractive to the growers because it imposes additional intensive labor requirements during installation and retrieval of the tubes. Some trickle tubing can be used effectively for only one season, thus imposing a severe economic constraint on the grower," says the researcher.

"Efficient use of water, fertilizer, and energy dictates the use of the trickle irrigation concept in water-short, semiarid regions such as the San Joaquin Valley in California. Potentially, the use of traveling trickle systems to improve irrigation efficiency or to recycle drainage water could also decrease both the need for drainage and the rate of soil salinization. In the San Joaquin Valley, for instance, this salinization continues to increase at about 12,000 acres a year," Phené concludes.

Dr. Claude J. Phené is located at the Water Management Research Laboratory, 5544 Air Terminal Drive, Fresno, CA 93737.—(By Paul Dean, ARS, Oakland, Calif.)

Quick Test for Sulfa Drugs in Hog Feed

A fast, simple, and inexpensive test for detecting sulfa drug residues in hog feed has been developed by Daniel P. Schwartz, ARS research chemist at the Eastern Regional Research Center near Philadelphia.

"With this test, an untrained person can screen a feed sample for sulfa in only 10 minutes," says Schwartz. "And it can save swine producers, feed manufacturers, and inspectors time and money, since feed samples need not be sent to a laboratory for analysis."

Pork producers are permitted to feed hogs limited amounts of sulfa drugs to promote faster weight gains and to control atrophic rhinitis, a respiratory disease of swine. Schwartz noted that this disease causes a significant portion of the $400 million lost annually from all swine respiratory infections.

According to Food and Drug Administration regulations, use of sulfa drugs in hog feed must be stopped at least 15 days before slaughter. USDA monitoring found, however, that a substantial percentage of the hogs reaching slaughter plants had excessive sulfa residues in their liver tissue.

The high violation levels were traced by USDA scientists to the use of contaminated feed during the 15-day withdrawal period. Nonmedicated feed was being contaminated by leftover sulfa-medicated ingredients in feed-mixing equipment and storage bins. Only a gram of sulfa—about the equivalent of two aspirin tablets—in a ton of feed is sufficient to create illegal sulfa levels (0.1 part per million) in liver tissue of swine.

The test has been prepared in kit form. Although the test kits are not yet available commercially, field trials have had good results, according to Schwartz. When sulfa is present at more than 0.15 part per million in the feed being tested, the colorless test solution turns lavender.

Dr. Daniel P. Schwartz is located at the Eastern Regional Research Center, 600 E. Mermaid Lane, Philadelphia, PA 19118.—(By Darien Small, ARS, Beltsville, Md.)

Erosion Control of Frozen Soil

Frozen soils may be a major cause of serious erosion losses that occur each year in the dryland grain region of the Pacific Northwest. Up to 15 tons of soil per acre were lost from frozen fields despite a complete absence of rainfall in a study conducted by ARS hydrologist John F. Zuzel, Pendleton, Ore.

The Pacific Northwest dryland grain region, about 8.5 million acres of cropland in eastern Oregon and Washington and western Idaho, possesses some of the most fertile and productive topsoil in the world. Unfortunately, erosion causes soil losses ranging from 2 to 25 tons per acre with some individual fields losing as much as 100 tons of soil per acre.

Previous investigations of the factors responsible for soil erosion in the area focused on runoff from rainfall and paid little attention to the effects of freezing. Zuzel, who began his study in 1979, has identified a chain of events that leads to runoff from frozen soils.

Zuzel says that the upper soil layers become saturated with water during the fall rains, then freeze to depths of 15 inches in the winter. A snow pack usually accumulates on the frozen soil, adding to the water available for runoff.

Warm, moist air masses from the Pacific condense water from the air onto the snow pack's surface which not only adds still more water to the snow pack, but also adds heat. The condensation process involves a change in state of the atmospheric water molecules from the vapor to the liquid phase. This change of state liberates large quantities of heat that thaw the snow pack.

Since the water infiltration rate of frozen soil is near zero, nearly all the water from the melting snow runs off, carrying with it detached particles of soil. As the rate of the melting snow increases, the velocity of downhill runoff increases and more soil particles are detached. Any rainfall released by the warm air adds further to the problem.

The amount of influence that management practices can have on runoff from frozen soils is yet to be determined.

Rills are the scars left by runoff — resulting not only from rainfall, but also from thawing top soil. According to an ARS researcher studying northwestern drylands, fall rains saturate upper soil layers and then freeze to depths of 15 inches in winter. As the ice and snow melt in spring, runoff gouges precious topsoil out of the earth (0579X641-30).

Zuzel observed in preliminary tests that leaving residue on the soil's surface in a reduced tillage operation prevented frost penetration to any great depth and the result was little or no runoff.

Zuzel says that more monitoring and observing are needed before any recommendations can be made. He would like one day to see a frozen soil runoff factor incorporated into the Universal Soil Loss equation which is now being adapted for predicting annual soil losses in the Pacific Northwest.

Dr. John F. Zuzel is located at the Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR 97330.—(By Lynn Yarris, ARS, Oakland, Calif.)

The Verticillium Connection— Alfalfa Wilt

Scanning electron-micrograph (magnification x 6,000) reveals verticillium wilt fungus as strands on internal part of alfalfa seed coat (PN-6823).

Verticillium wilt, the devastating disease of alfalfa long believed to be transmitted through debris or other surface contaminating material, can be carried within the alfalfa seed itself, an ARS funded study has shown.

Alice A. Christen, a plant pathologist with Washington State University (WSU) at Prosser, working under a cooperative agreement between WSU and ARS, found that verticillium wilt can exist inside the alfalfa seed coat. This means that no amount of seed cleaning can prevent the disease from being spread.

Verticillium wilt is a major production hazard for alfalfa growers throughout the Northwest and was reported in Wisconsin in 1980. It is estimated that about half the alfalfa acreage in the Northwest is affected by the disease. Once established, the only effective treatment is crop rotation with 2 or more years out of alfalfa. Otherwise, alfalfa yields deteriorate until, by the third year of infestation, the plants become unprofitable to grow.

Cleaning debris from seed was thought to be an effective way to contain verticillium. But Christen surface-sterilized greenhouse-produced alfalfa seed to remove all possible external contaminants and still found the organism in a low percentage of seed from her inoculated test plants. Examination of the interior of the seed coat by scanning electron-microscopy revealed that the fungus is contained within the seed. "This is not simply a greenhouse phenomenon," she says, "It also occurs in the field."

Christen says that all alfalfa seed from a verticillium-infected field could be suspect. Several methods including systemic pesticides and heat are now being tested for effectiveness as a seed treatment to limit spread of the organism.

The best control of the disease will probably be through use of wilt-resistant alfalfa varieties. ARS agronomist Richard N. Peaden, who first identified the disease's presence in the Northwest, is now working with experimental alfalfa lines that so far show good verticillium resistance.

Dr. Alice A. Christen and Dr. Richard N. Peaden are located at the Irrigated Agriculture Research and Extension Center, P.O. Box 30, Prosser, WA 99350.—(By Lynn Yarris, ARS, Oakland, Calif.)

Beneficial Nematodes Control Tree Pests

Nematodes, those tiny near-microscopic worms that are often parasitic to plants and animals, are not all bad. Some are helpful.

One nematode that is a parasite of insects is being used successfully as a "biological insecticide" to rid fig trees of the carpenterworm. Fig production in California amounts to an on-the-farm-value of about $4 million.

Carpenterworm larvae are destructive wood-boring insects that attack several tree varieties and infest fig orchards in the San Joaquin Valley, Calif.

The larvae bore into the heartwood of the tree creating galleries that weaken the tree which results in localized girdling, possible fungal invasion, and broken limbs. Damage can be extensive enough to kill the tree. Short of that, yields can be drastically reduced.

Infestations have been found in all of the major fig varieties in California. Black Mission and Kadota varieties appear to be the most susceptible, averaging from a low of 10 percent to as much as 94 percent infestations in some orchards.

James A. Lindegren, ARS entomologist, Fresno, has had as much as 98 percent control of the carpenterworm by using a nematode called *Neoaplectana carpocapsae Weiser*. Bill Barnett, Fresno Extension county farm advisor, first brought the problem to Lindegren's attention. The two, with the assistance of Tom Yamashita, biological technician—funded in part by the California Fig Institute and the Almond Board of California—have since cooperated in the control effort.

This particular nematode—it is also being studied to aid naval orangeworm control in almond orchards—is an interesting phenomenon. It carries within itself a bacterium that actually does the killing of a susceptible insect host. While the bacterium is destroying the insect and multiplying itself, the nematode uses the resultant bacteria as its food supply. A mutuality exists between the bacterium and the nematode and one cannot exist in nature without the other.

The nematode can last about 10 days in a damp cryptlike environment such as found in the galleries. When the parasitized insect host dies, the gallery dries, killing the nematode and its bacteria.

Lindegren has had his best results with doses of about 100,000 nematodes per gallery at 2 millimeters per application—about the volume of ¼ of a teaspoon.

Once in the galleries, the nematodes actively seek out the insect in the maze of galleries, something chemical insecticides could not possibly do.

Gallery openings are fairly easy to spot. The researchers seek out those galleries and spray the nematode solution—water, plus super-slurper, a water absorbent material to "thicken" the solution and keep the nematodes in suspension—into the opening. One "squirt" from an oil can puts about 17,000 nematodes into the opening. The nematodes then seek out the insect larva infesting the gallery. In most instances, there is only one insect larva per gallery since they are cannabalistic and do not tolerate intruders.

Several "applicators" have been used to apply the solution—a backpack sprayer, a pressure-type oil can, and even a large medical syringe.

The best time to apply the suspension, Lindegren says, is in the early morning. Carpenterworm larvae periodically clean out the accumulated frass—refuse left by such boring insects—during late afternoon and dusk. By applying the suspension in the morning, more time is allowed for the near-microscopic nematodes to penetrate the "clean" gallery interior. Once the larvae are infested, they last no more than 6 days.

Female carpenterworms lay eggs in roughened bark and indented surfaces such as pruning wounds and scars. Larvae have been seen to react unfavorably to the white sap exudate of the fig tree which may be a natural defensive barrier.

Successful invasion sites appear to center about pruning scars, where partially-healed stubs allow initial access to the heartwood without direct exposure to the bark's apparent sap barrier.

"Abandoned galleries are also reinfested by newly emerged larvae," Lindegren says.

"Localized distribution of carpenterworm larvae in fig orchards indicates that the movement of the newly emerged heavy-bodied female moth—they cannot and do not fly very far—is normally limited to nearby trees. The elimination of carpenterworm infestation from the fig orchards and adjacent, susceptible, native and ornamental trees may provide for long term eradication of this insect pest," Lindegren says.

"This method of controlling the carpenterworm is simple, inexpensive and apparently successful" Lindegren says. "The only thing left, after clearance by the Environmental Protection Agency, is a method of supplying nematodes to growers desiring to use the technique in their orchards."

Thus far, the researchers have been mass-rearing the nematodes by infesting insects in the laboratory. Lindegren has also mass-reared nematodes using a commercial dog food. That method is less complicated and more inexpensive than using live insects. He is also trying to devise a method whereby growers might possibly raise their own nematodes.

A commercial firm in Fresno that raises crickets for fishbait recently began raising nematodes during the off-season. These nematodes are being supplied to researchers. After EPA clearance, nematodes will be sold to growers by the company.

Dr. James E. Lindegren is located at the ARS Stored Product Insect Laboratory, 5578 Air Terminal Drive, Fresno, Calif. 93727.—(By Paul Dean, ARS, Oakland, Calif.)

Screening Strawberry Seedlings

ARS scientists at Poplarville, Miss., and Beltsville, Md., in cooperation with the state agricultural experiment stations of Louisiana, Florida, and North Carolina are currently working to develop strawberry varieties resistant to anthracnose and also adaptable to the strawberry-growing regions of the southeastern United States.

Strawberry anthracnose, commonly called crown rot disease, has reduced Louisiana's strawberry acreage from 17,800 acres in 1947 to 600 acres in 1981. The disease has also devastated widespread strawberry acreage along the Gulf Coast States, including Florida, and as far north as North Carolina. This is one of the major reasons why growers in the South must destroy their strawberry plants each year after fruiting in April and May. Strawberries are usually grown for about 3 years in other areas of the United States before replanting.

The high temperatures and humidity found along the Gulf Coast favor disease development, especially from June through August. However, when temperatures cool, usually in late summer and fall, and humidity drops, the incidence of disease begins to slow. Even infected plants may do well through winter and spring, but die as soon as hot weather arrives. The overwintering of infected plants allows the fungus to persist from year to year and from field to field.

ARS plant pathologist Barbara J. Smith, U.S. Small Fruit Research Station in Poplarville, Miss., is currently screening 30,000 to 50,000 seedlings each winter in a 30-foot by 60-foot fiberglass house for resistance to crown rot. She says, "It takes 6 months or less from seeding to having potentially resistant plants ready to try in the field."

Developing a resistant strawberry variety, however, could take from 5 to 15 more years, according to Smith.

Ms. Barbara J. Smith is located at the U.S. Small Fruit Research Station, P.O. Box 287, Poplarville, MS 39470.—(By Neal Duncan, ARS, New Orleans, La.)

Beneficial Inhabitants of the Soil

A gram of soil in a farmer's field may contain from one to more than 10 million microorganisms that modify the soil's physical and chemical environment as they carry out their life processes.

The environment in which these beneficial soil inhabitants live is apparently quite different under reduced or no-till soil management systems from their environment under conventional tillage, says ARS soil scientist John W. Doran.

"The no-till ecosystem approaches that of undisturbed soil, such as native grassland," Doran says. "Breakdown of soil organic matter by oxidation in the tillage layer and the associated decrease in long-term productivity with cultivation apparently are decreased by reducing tillage."

No-till surface soils also contain more carbon, nitrogen, and water than plowed soils. But the no-till surface soils are more favorable to microbial growth which provides a greater chance for immobilization of nitrogen in a form not available to plants.

In the top 3 inches of long-term no-till plots, Doran found 11 to 93 more pounds of nitrogen per acre that might be immobilized in microbial biomass.

Doran says this increased potential for immobilization of fertilizer nitrogen leaves less nitrogen available to plants as nitrate, indicating that present tillage and management practices must be altered under reduced tillage. He is a member of a research team at Lincoln, Nebr. that is looking into all aspects of conservation tillage with the goal of recommending how it can be improved.

No-till and other reduced tillage systems that maintain crop residues near the soil surface originally were developed to reduce soil erosion losses and conserve soil water for greater crop production in semiarid areas. These systems now have added appeal because using fewer tillage operations saves energy and labor.

Soil microorganisms have a primary role—along with earthworms and plants—in building and stabilizing soil structure. They help to arrange soil particles into clustered masses ranging in size from microscopic to clods. Structure, in turn, has a major influence on the soil's air and water content and on its temperature and mechanical resistance to root penetration.

"In short, a soil with good structure takes up water better, resists surface erosion, and is a favorable environment for plants," Doran says.

The intricate scheme of energy and nutrient transfer among soil organisms is often called a "food chain" or "food web." Doran believes "food web" is more descriptive.

The biomass of microorganisms, earthworms, and other macroorganisms in the surface 6 inches of field soil may total 1,800 to 8,900 pounds per acre. Microorganisms can make up 90 percent or more of this biomass weight.

Plants and algae produce the original sources of food in the food web through photosynthesis—by capturing energy from sunlight to make sugars from carbon dioxide and water. In turn, fungi, actinomycetes and other bacteria, and earthworms decompose these materials. Then protozoa, nematodes, and other organisms feed upon the bodies of the primary decomposers. Earthworms and other microorganisms feed on both the plant residues and the smaller organisms.

The products of decomposition are highly important in forming and stabilizing soil structure, Doran says. Without biological transformation, the addition of organic matter has little effect on soil structure. The primary decomposers carry on 60 to 80 percent of the soil's metabolic activity, and their effects on forming and stabilizing soil structure can be seen as changes in water intake, aeration, and resistance to surface erosion.

The surface soil's bacterial population includes both nitrifiers, which convert

Young soybean grows amid grain stubble in no-till soil. (Photo courtesy of Grant Heilman.)

organic nitrogen to nitrites and then to nitrates, and denitrifiers, which break down nitrate and nitrites. The nitrifiers are aerobic (oxygen-requiring), while the denitrifiers are either anaerobic—functioning only in an oxygen-free environment—or facultative anaerobes able to function in either environment.

How does reduced tillage affect these soil microbial populations?

Increased quantities of surface residues from corn and wheat with minimum tillage produced a two- to six-fold rise in the number of fungi, actinomycetes, and other bacteria in the top 3 inches of soil in a study by University of Nebraska graduate research assistant Daniel M. Linn and Doran. Surface mulching also increased denitrifying organisms 31 to 44 times and nitrifying organisms 2 to 4 times.

Doran's study of the long-term tillage plots at eight U.S. locations indicates a less oxidative environment with no-till, and the larger microbial population is concentrated nearer the surface than in plowed plots.

With no-till, microbial populations decrease rapidly below 3 inches of soil. At a 3- to 6-inch depth, microorganisms and nitrifiers were 1.3 to 1.8 times more numerous than on conventionally tilled soils. In contrast, denitrifiers were 1.2 to 1.8 times more numerous with no-till. In addition, the proportion of the total population made up of denitrifiers was twice as great with no-till.

Doran says certain soil enzymes seem to be related to both the activity of microbial populations and the availability of organic matter. Assays for these enzymes, when further tested and standardized, should be useful in classifying surface soils according to microbial activity.

Dr. John W. Doran is located at 116 Kein Hall, University of Nebraska, East Campus, Lincoln, NE 68583.—(By Walter Martin, ARS, Peoria, Ill.)

Field Burning and the Environment

"Burning fields used for grass seed production is the cheapest, most effective, and least environmentally damaging method of controlling diseases and weeds now available," says retired ARS plant pathologist John R. Hardison, Corvallis, Ore.

According to Hardison, who has been studying grass seed production and field burning since 1944, "No substitute for the inexpensive, time-honored practice of open field burning is capable of supplying the thermal sanitation needed for grass seed production."

The researcher explains that mobile field burners and flaming devices have been investigated thoroughly and found to be extravagant users of fossil fuels, and severely limited in effectiveness.

The West, with its low summer rainfall and humidity, produces much of the grass seed grown in this country. Conditions favoring disease and weed problems develop with increasing intensity each season after harvest.

For the past 30 years, growers have burned their grass fields to remove the straw and stubble, where diseases flourish, and to kill weed seed at the soil surface. In recent years, this method has been criticized because of the air pollution it can cause.

Hardison, a pioneer in field burning, says that proper burning techniques under a good smoke management program can alleviate the air pollution problem. "The Oregon State University Air Resources Center found that rapid ignition of residue on the entire field perimeter creates a fast fire with an upward draft that draws smoke into a convective column that effectively elevates it to an altitude sufficient for good dispersal by lateral air currents," says Hardison.

Farmers should burn fields only when atmospheric conditions are conducive to transporting the smoke away from sensitive areas, such as population centers, he adds.

Hardison says that with good smoke control, field burning can even help the environment by reducing the need for pesticides. "Field burning controls blind seed disease, ergot, grass seed nematode, and silver top," he says. "It also kills 95 to 99 percent of the weed seed at the soil's surface.

"What is needed is refinement of burning techniques. Improved techniques and better public understanding should enable the grass seed industry to continue this needed practice."

Dr. John R. Hardison is located at Oregon State University, Cordley Hall, Room 2074, Corvallis, OR 97331.—(By Lynn Yarris, ARS, Oakland, Calif.)

Proper burning techniques can diminish air pollution problems on ground level by elevating smoke column to an altitude sufficient for good dispersal by lateral air currents (PN-6824).

Growth Regulators Increase Seed Yields

Chemicals that revitalize crops dying of old age sometimes act like potions to encourage renewed flowering and increased seed yields.

Why just sometimes? That's a question addressed in ongoing field tests by ARS plant physiologist C. Dean Dybing and fellow researchers at South Dakota State University, Brookings.

The chemicals belong to a group of plant growth regulators called morphactins.

"Morphactins could help revive the flax industry if we discover how to get them to be consistent in increasing yields of seed with high-oil content," says Dybing. "Timing of the chemical treatment to coincide with a short period just after the plants bloom is apparently critical. Yield has increased as much as 15 percent and oil content as much as 12 percent with their use, but in some years yields have been reduced as much as 15 percent."

Aside from increasing flax yields, a more far-reaching payoff from the research may come from the scientists gaining insights into the physiology of seed production or how life processes—photosynthesis, respiration and growth—relate to yields of a number of other crops.

New knowledge of the physiology of seed production might speed up development of high-yielding crop varieties or help scientists define cultural practices that lead to high yields. Because of this, the researchers have applied morphactins to plots of soybeans and small grains as well as to flax.

Morphactins failed to increase soybean yields but they delayed senescence, or old age, of the plants when applied in the late-pod stage at a very low rate—0.35 ounces per acre. In contrast, the chemical sometimes increased wheat the oat yields but failed to delay senescence.

Two plant growth regulators that figured most prominently in the study were the morphactins, chlorflurenol and dichlorflurenol.

Chlorflurenol was the most potent. Leaves stayed green longer and stayed on the plants longer. From anatomical studies on soybeans, the scientists determined that cells past their prime had resumed division and growth.

Can the growing season for this field of flax be extended? (Photo Courtesy of Grant Heilman.)

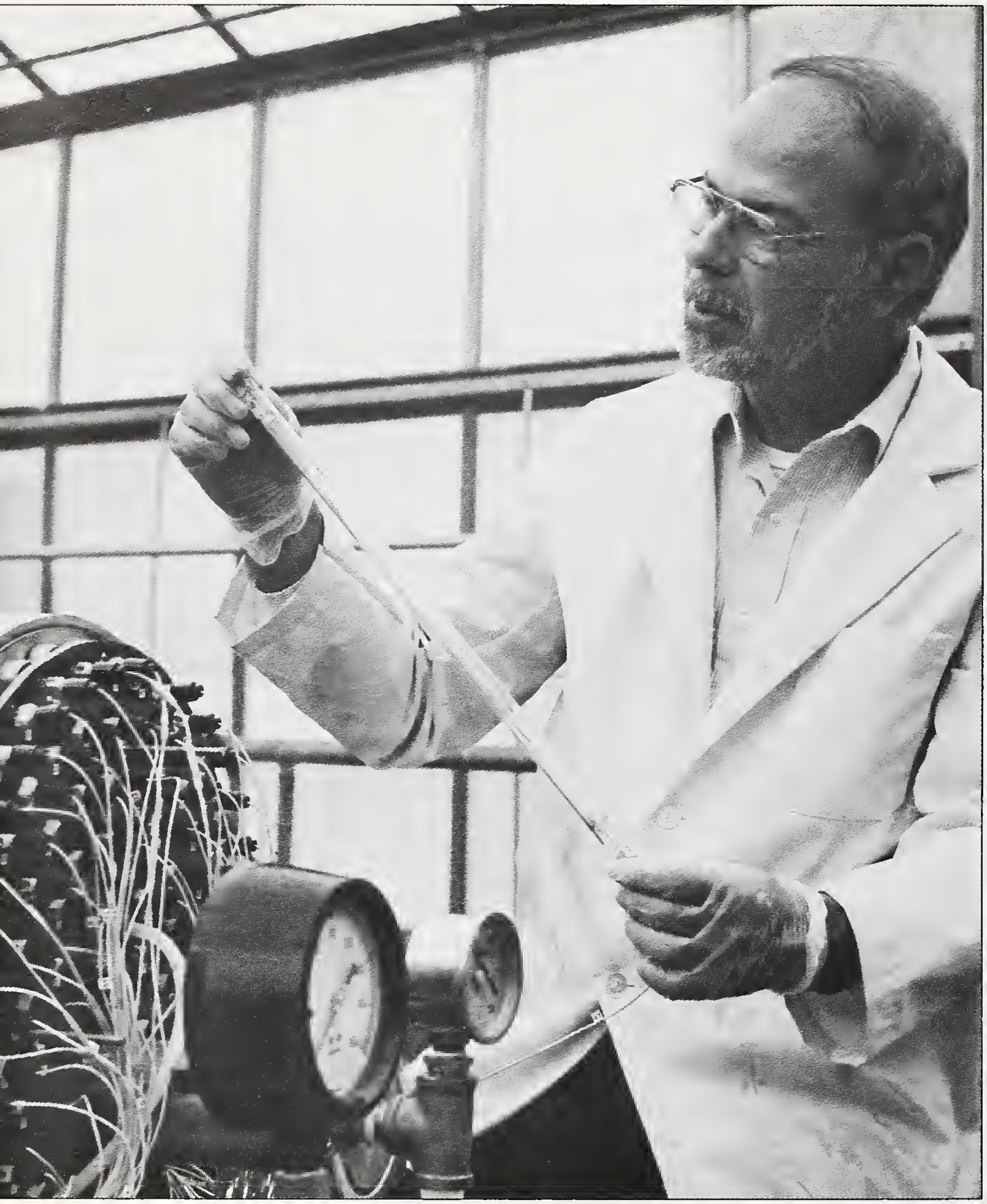
"Some crops including flax and small grains don't use all the growing season before senescing," Dybing says. "The question is—can we get them to benefit from the approximately one quarter of the season that is unused?"

Even though plants are kept alive longer, they will apparently face difficulties which may prevent an increase in yield in some years. These difficulties include small size of new seeds, preharvest loss of ripe seed while new seeds are forming, low seed set in new flowers, and increasing effects of leaf diseases.

Additional research may help scientists clearly define field conditions that are needed to make application of morphactins reliably benefit crops. The experimental compounds that Dybing used are not presently licensed by the Environmental Protection Agency for crop use.

Dr. C. Dean Dybing is located in room 153B, Plant Science Building, South Dakota State University, Brookings, SD 57006.—(By Ben Hardin, ARS, Peoria, Ill.)

Toxic Liquid Wastes Now Biodegradable



Soil microorganisms can break down certain toxic liquid wastes only after highly stable chemical bonds have been loosened by UV radiation. Philip Kearney, ARS chemist, inspects one of 66 tubes that generate UV radiation to chemical solutions cycled through an irradiation system (0881A947-23a).

The question of how to dispose of some toxic liquid wastes may now have an answer.

It seems that soil microorganisms—nature's most efficient recyclers—can dismantle even highly stable chlorinated organic compounds after ultraviolet (UV) radiation loosens a few "bolts."

Philip C. Kearney and Jack R. Plimmer, ARS chemists, Beltsville, Md., loosened the bolts by subjecting solutions of stable chemicals to UV radiation before adding them to soil, where the soil microorganisms take over. The result, based on laboratory-scale trials, was a dramatic improvement in the decomposition of each of the compounds tested. They were PCB's (polychlorinated biphenyls), PCP (pentachlorophenol), and 2,4,5-T and its contaminant, dioxin.

The UV pretreatment works only when the compounds are dissolved in water, and is most effective when the solutions are dilute—about 1 part per million. Because of these limitations, Kearney sees its present potential in cleaning up small waste lagoons around the country. But he does not discount adapting the scientific principle behind this method to large toxic waste disposal sites. "This is a real breakthrough in decontaminating liquid wastes based on proven chemical and biological principles," Kearney says. Plimmer agrees, "It's a matter of engineering, but the scale of it can be increased."

While the use of short-wavelength radiation to break down stable chemicals is not new, the idea of using it in conjunction with microorganisms for safe disposal of these chemicals had its genesis at Beltsville. Incineration, the method currently recommended for disposing of chlorinated organic chemicals, is very energy consumptive.

Many chemicals can be safely disposed of in soil because they are readily decomposed by soil microorganisms. But some of the chlorine-carbon bonds in chlorinated organic compounds are highly resistant to the enzymes of these microorganisms. Once these bonds are severed, microorganisms can dismantle the rest of the chemical, explains Kearney.

To break these bonds, Kearney, Plimmer, and visiting scientist Z. M. Li exposed the dilute solutions to UV light for at least 1 hour and bubbled oxygen through the solutions to speed the breakup. The irradiated solutions were poured over soil contained in special flasks, and the amount of carbon dioxide generated was measured to determine the percentage of decomposition.

Result? Over 80 percent of UV-treated

2,4,5-T decomposed during a month in soil as contrasted with about 15 percent for the untreated solution—a better than fivefold increase. Decomposition of PCP improved from 20 to 75 percent. Kearney believes that the system can be fine-tuned to cause almost complete decomposition and to reduce UV irradiation time.

PCB's proved to be most difficult to degrade—only 20 percent decomposition; however, that rate was 20 times higher than the untreated sample, which remained virtually intact. Dioxin, the most hazardous chemical evaluated, required a much longer period of irradiation than the others to achieve 60 percent decomposition. For all four compounds, most of the decomposition occurred during the first day or two in soil.

Kearney says that UV pretreatment would be less disruptive to the soil than pretreating wastes with strong chemicals. "It won't kill soil microorganisms or alter soil pH," he stated.

While the technique needs more experimental work, Kearney is highly optimistic about its practical use. He envisions a mobile disposal unit that could be transported from farm to farm. He and his colleagues are currently experimenting with a prototype system that includes a 55-gallon stainless steel drum as a holding tank and a commercial water purifying unit as the UV source.

At the same time, an ARS microbiologist with the group, Donald D. Kaufman, is searching for more efficient microorganisms, "superdegraders," that can be added to a disposal area prior to spraying the treated wastewater.

Dr. Philip C. Kearney and Dr. Donald D. Kaufman are located in Room 100, Bldg. 050 and Dr. Jack Plimmer in Room 236, Bldg. 007, Beltsville Agricultural Research Center, Beltsville, MD 20705.—(By Judy McBride, ARS, Beltsville, Md.)

Antibiotics for Plants

In the world according to plants, life is an ongoing war of chemicals with only the outcome of individual battles visible to the naked eye. ARS scientists are learning how to tip the balance of this warfare to what humanity sees as the "good" side.

The soil within the influence of a plant's root system—called the rhizosphere—is a hotbed of microbial activity where bacteria beneficial to plants clash constantly with disease-causing microorganisms called pathogens.

Microorganisms utilize sugars and amino acids that are given off by plants. Metabolites released by pathogens can inhibit plant growth and sometimes cause other problems, such as disease. Beneficial bacteria living in a plant's rhizosphere release their own metabolites which sometimes inhibit pathogens and enhance plant growth.

At ARS Ornamental Plants Research Laboratory, Corvallis, Ore., test soils are being artifically inoculated with naturally occurring bacteria that will act as antibiotics, overwhelming pathogens in the soil and enabling plant growth to increase.

"What we are attempting to do is create a pathogen-suppressive soil," says Robert G. Linderman, ARS plant pathologist and leader of research at the Laboratory. "If a pathogen is unable to infect a host plant within a given period of time, it may die."

Linderman says that the pathogen-suppressive soil conditions can be maintained "as long as necessary." Bacteria now being used at the laboratory can be grown, protected and easily incorporated into the soil.

Though a wide range of bacteria beneficial to plants has already been identified, the search for additional beneficial bacteria continues. "Since disease is the exception in nature, biological control must exist everywhere," says Linderman.

So far, beneficial bacteria tests have been limited to small-scale laboratory studies. The next step is to run greenhouse trials. Since ornamental plants are grown indoors where the environment can be completely controlled and manipulated, ornamentals are especially well suited for this work.

Robert G. Linderman examines plants for signs of beneficial microorgamisms (0381X311-32).

For the same reason, the ornamental plants industry—a $4.8 billion retail business in the U.S. alone—stands to benefit most from the use of the beneficial bacteria. However, the principle should be applicable to all other crops.

Dr. Robert G. Linderman is located at the Ornamental Plants Research Laboratory, 3420 Southwest Orchard Street, Corvallis, OR 97330.—(By Lynn Yarris, ARS, Oakland, Calif.)

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Agrisearch Notes

Fescue Grass Delays Conception in Ewes. Ewes grazing tall fescue pastures take two to three times longer to conceive than those grazing orchardgrass pastures, according to studies at the Ruminant Nutrition Laboratory in Beltsville, Md.

G. Paul Lynch, ARS animal physiologist and James Bond, ARS animal nutritionist, are monitoring the nutritional value of experimental plots of tall fescue using pregnant ewes. Tall fescue, grown on about 33 million acres in the United States is a versatile and durable forage crop, ideal for grazing.

Delayed conception extends the lambing season, and this increases the need for farm labor, which is costly to sheep breeders. In addition, lambs may be born during summer, when heat and parasitic infections decrease feed efficiency. Also, delayed lambing decreases the chance of producing three lamb crops in 2 years.

Lynch, Bond, and their coworkers divided 36 crossbred ewes into six groups and placed them in half-hectare pastures from June to November. All pastures contained pure stands of forages. Two contained an experimental variety (307) of tall fescue; two contained Kentucky 31, a commonly grown tall fescue; and two contained orchardgrass. Ewes were bred by rams placed in these pastures. These rams were periodically rotated from one group of ewes to another.

In November, these ewes were moved into drylots and each fed a half pound of grain per day, plus all the hay they would eat. The hay was from the same pasture that they had been grazing. The type of pasture and hay did not affect their weight gains.

Delayed conception time was the only way that sheep on fescue differed from those on orchardgrass. Ewes did not change their eating behavior or show symptoms of fescue toxicity, which is probably caused by toxins or fungus in this grass.

Ewes from the various pastures did not differ in gestation length, average number of lambs, weight of lambs at birth, or lamb survival up to 60 days of age.

These studies show that fescue contains something that delays conception in sheep. Lynch and his coworkers are planning further experiments to determine what causes this delay.

Dr. G. Paul Lynch and Dr. James Bond are located in Room 118, Building 200, Ruminant Nutrition Laboratory, Beltsville, MD 20705.—(By Henry Becker III, ARS, Washington, D.C.)

New Nematode Discovered. A new nematode species that attacks potatoes has been discovered in the Pacific Northwest. Growers in the area with this problem may have to change their crop rotation practices to combat the new pest.

Discovered by two nematologists, John O'Bannon, ARS, and Gerald S. Santo, Washington State University, both at Prosser, Wash., the new pest is called Columbia root-knot nematode (*Meloidogyne chitwoodi*).

This discovery was the result of an investigation triggered by reports of severe nematode damage to several potato fields in 1978 and 1979 that did not fit the pattern expected from the Northwest's traditional nematode potato pest, the Northern root-knot nematode. Damaged potatoes were found along the Snake River in Idaho and in Washington and Oregon. Recently, the Columbia root-knot nematode has also been found in Northern California and Nevada.

Growers in these states routinely rotate potatoes with wheat to control the Northern root-knot nematode. Studies have shown, however, that wheat is a prime host for the Columbia root-knot nematode and growers with this pest should probably rotate to alfalfa instead. Since alfalfa is a host plant for the Northern root-knot nematode, Northwest growers should check their fields for both nematode species.

Other hosts for Columbia root-knot nematodes that have been identified are corn, oats and barley, sugarbeets, and tomatoes. Symptoms of infestations in these hosts and in wheat, however, are not always evident. New bioassays to assess soil for Columbia root-knot presence will have to be developed.

Though the damage to potatoes caused by the two nematode species is the same—galls or lumps form on the surface of tubers and brown spots appear internally—Columbia root-knot nematodes may infest tubers more rapidly. Yields are not affected too much, but quality is severely reduced. Tubers get downgraded and are ruined for the processing market.

Early indications are that the new nematode is much more aggressive in its ability to invade and reproduce at lower temperatures than the Northern root-knot nematode.

Fumigation treatments used successfully on Northern root-knot nematodes have not been as effective when used on Columbia root-knot nematodes. Studies are being continued to learn more about this new pest.

Dr. John O'Bannon is located at the Irrigated Agriculture Reseach and Extension Center, P.O. Box 30, Prosser, WA 99350.—(By Lynn Yarris, ARS, Oakland, Calif.)