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March 1983

Agricultural Research

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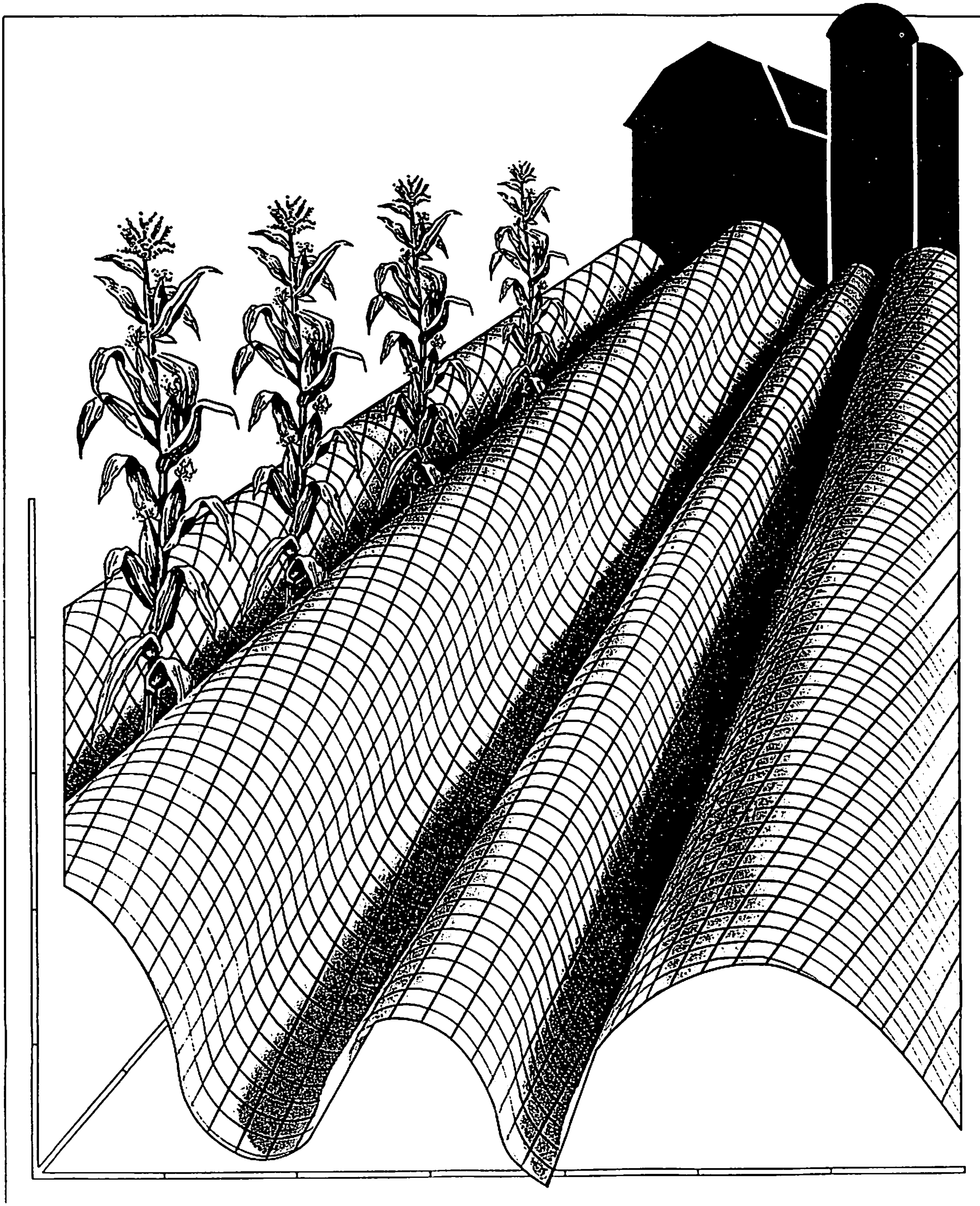

"We should set a goal of applying no-till or ridge till—some form of conservation tillage—on every suitable acre of U.S. cropland by the end of the century. I predict this Nation's agricultural community will achieve that goal."

That prediction comes from Terry B. Kinney, Jr., administrator of USDA's Agricultural Research Service, who says: "Conservation or minimum tillage decidedly is coming of age as scientists, advisors, and farmers smooth out the rough edges on a farm practice that can do more to preserve this Nation's soil and water heritage than any other single farm practice."

"For the good of the Nation we must shorten the time between achievement of conservation research results and the application of those results in the field," Kinney says. "Extension's role in disseminating research findings is essential, and this responsibility will increase as the role of technological development accelerates. Research laboratories and field stations in the public and private sectors have many new methods, techniques, and tools available that must be more fully utilized.

"We can't afford the luxury of time. Much U.S. cropland is losing 5 tons per acre of soil or more annually. In some areas, erosion rates where corn, soybeans, or cotton are grown are between 13 and 25 tons an acre each year."

The various forms of conservation tillage leave crop residues on the soil surface where they help reduce soil and water losses. Crops are then planted with the least possible disturbance of residue.

"A few years ago," Kinney continues, "most farmers wouldn't hear of tillage methods that left residue on top of the soil. Now, about 100 million U.S. acres are minimum tilled or not tilled at all in cropping systems, according to USDA's Soil Conservation Service. These 100 million acres are nearly a fourth of the total 413 million acres of U.S. cropland."

Kinney bases his optimistic prediction for the year 2000 on farmer interest and action, yes, but also on research progress and education.

"Perhaps the most unique challenge," Kinney says, "is that no-till management, particularly, modifies the soil's physical, organic, microbiological, and chemical environments, thus mandating changes in basic farming practices and equipment.

"These challenges are being faced—and solutions are being found—by multidisciplinary teams of ARS scientists and engineers often working with their counterparts in land-grant universities and in industry. It is a well-coordinated effort at several ARS research locations reflecting the many variables of agricultural production—climate, weather, soils, topography, economics, management, crops, livestock, pests, and types of farming."

Kinney is supported in his position on conservation tillage by many U.S. agricultural leaders and scientists who also are aware of unanswered challenges. One is William C. Moldenhauer, nationally recognized ARS soils authority, West Lafayette, Ind.

Moldenhauer believes no-till and ridge till with surface residue are feasible on most soils in the Corn Belt. When he says this, he recognizes that drainage and cropping history can be drawbacks, but he says drainage is a problem separate from tillage and must be resolved separately either through additional research leading to new methods or through known methods. He recognizes too that no-till and ridge till may have to be supported on long, moderately steep slopes by such other practices as contour planting, terracing, or cover crops.

Research administrator Kinney cites that farmers of this Nation have been able to maintain or increase soil productivity in recent decades largely through soil testing and the addition of commercial fertilizers. "But," he emphasizes, "we will soon reach a point of diminishing economic returns from fertilizer application if soil losses continue at present rates, and if our cropland base continues to diminish through erosion and loss of land to other uses. Each year 3 million acres of rural land is lost to nonfarm use, including a million acres of prime farmland."

Beyond soils, Kinney says, U.S. agricultural production may be limited most in the future by shortage of water—that lost through runoff, by shrinking ground water reserves, and to growing demands of other sectors of the economy. Agriculture is this Nation's largest consumer of water; four times more is consumed, mostly by irrigation, to produce food, fiber, and feed than for all other purposes combined. And needs by manufacturing, mining, and generating electricity are expected to increase much more rapidly in the future than use of water for agriculture.

"Certainly," Kinney continues, "anything we can do to keep water from running off the land and to cause it to soak into the soil or down into groundwater storage will help ease water shortages now and in the future. This includes no-till and other forms of conservation tillage—practices that will also relieve the problem of silting of ponds, reservoirs, and lakes—a process that can reduce water-holding capacity substantially in a relatively short time.

"But we must also learn more about recycling waste waters, irrigating with brackish or salty water, irrigating by growth stages of crops, and breeding crops that are salt tolerant and drought resistant. All of these potential and present practices will help us utilize water more efficiently, but they must also be cost effective if they are to be put to use."

Recent studies on the cost effectiveness of conservation tillage show it can increase returns by 10 percent on well-drained soils.

For its role in helping to improve the economics of farming and preserve our natural resource heritage, Kinney looks to conservation tillage as the predominant tillage method of the future for American farmers.

Robert E. Enlow
Peoria, Ill.

Beginning with this issue, Agricultural Research *magazine will join in a special effort to inform farmers and others of current research results supporting soil and water conservation. This month's issue focuses on soil erosion. Subsequent issues will report on improving tillage practices (April); maintaining or increasing soil productivity (May); reducing pollution and sedimentation (June); using water efficiently (July-August); and improving irrigation and drainage (September).*

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Agricultural Research
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Acting Assistant Editor: Joan Blake
Photography Editor: Robert C. Bjork
Art Director: Deborah Shelton
Circulation Manager: Charles Jones

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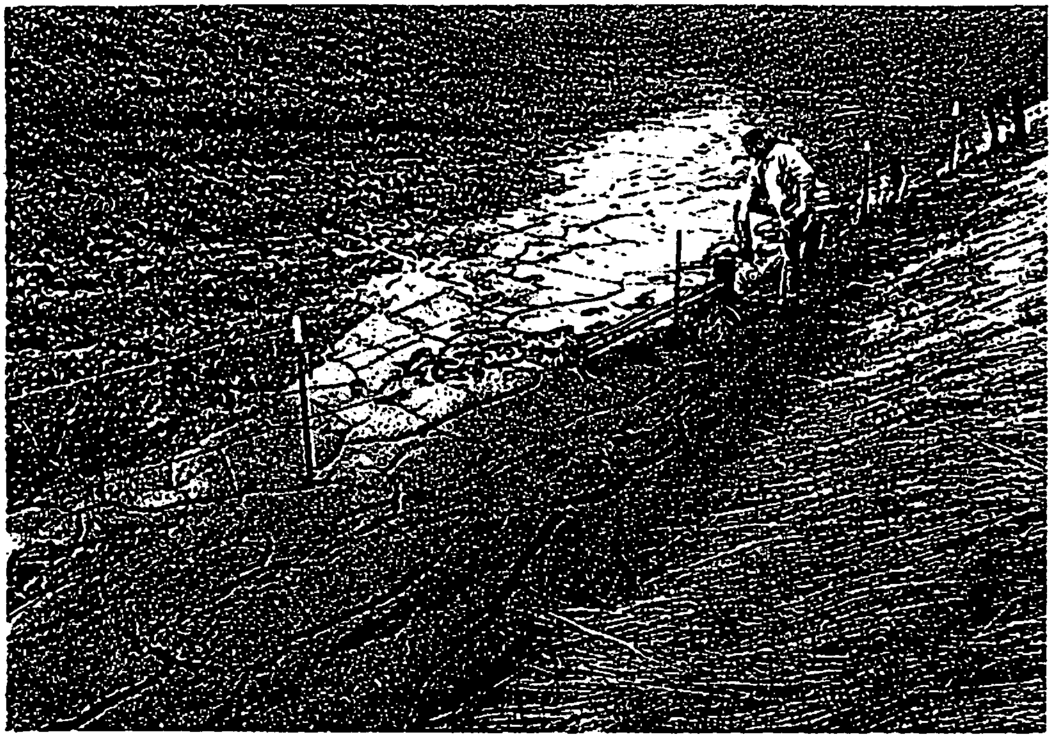
John R. Block, Secretary
U.S. Department of Agriculture

Orville G. Bentley
Assistant Secretary
Science and Education

Terry B. Kinney, Jr.
Administrator
Agricultural Research Service

Cover: X-y axes, graphs, and real-life measurements are just some of the components of computer modeling for agriculture that figure in this artist's conception. Computer-generated models of agriculture are becoming increasingly sophisticated, realistic, and valuable as a diagnostic and forecasting tool for researchers and planners alike. One such model—EPIC—created by ARS scientists in Temple, Tex., forecasts the progression of soil erosion and its effects on crop productivity. Article begins on p. 4. (PN-7046)

Soil Productivity Modeling Through EPIC



Although soil erosion continues to devastate valuable farmland, its rate has slowed considerably with the widespread application of conservation knowledge gained through years of research. To make the best use of our remaining soil resources, agricultural scientists must now learn more about the complex relationship between soil erosion, tillage conditions, and soil fertility. (0579X642-32A)

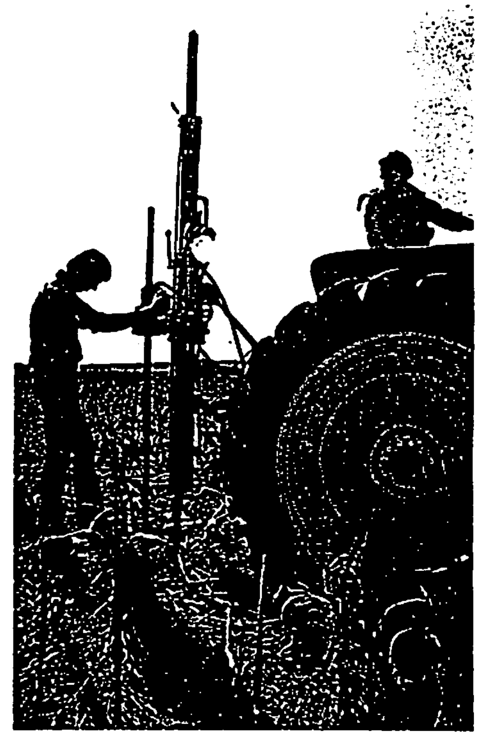
Computers may soon be forecasting for the first time what effect soil erosion has on crop productivity for all of the United States—for a period of several hundred years, if necessary.

A multidisciplinary team of 13 ARS scientists and an economist from USDA's Economic Research Service has put together a computer system to keep tabs on and forecast how the rate of soil erosion, a relatively slow but disastrous process, will affect soil productivity (its capacity in its normal environment to produce a specific plant or sequence of plants under a specific management system). The modeling team is headed up by Jimmy R. Williams, hydraulic engineer, at ARS's Grasslands, Soil and Water Research Laboratory, Temple, Tex. The team has completed all the initial testing of the model and the system is expected to go "on line" in the spring.

This is just in time for the annual spring thaw with all the erosion problems it causes. According to national estimates, each year the United States loses about 5.5 billion tons of topsoil. The Mississippi River alone carries off enough land annually to build an island 1 mile long, ¼ mile wide, and 200 feet high. And in eastern Washington each June, the Palouse River carries away about 3 million tons of fertile topsoil—enough to cover an area eight blocks square, eight stories high in less than a century.

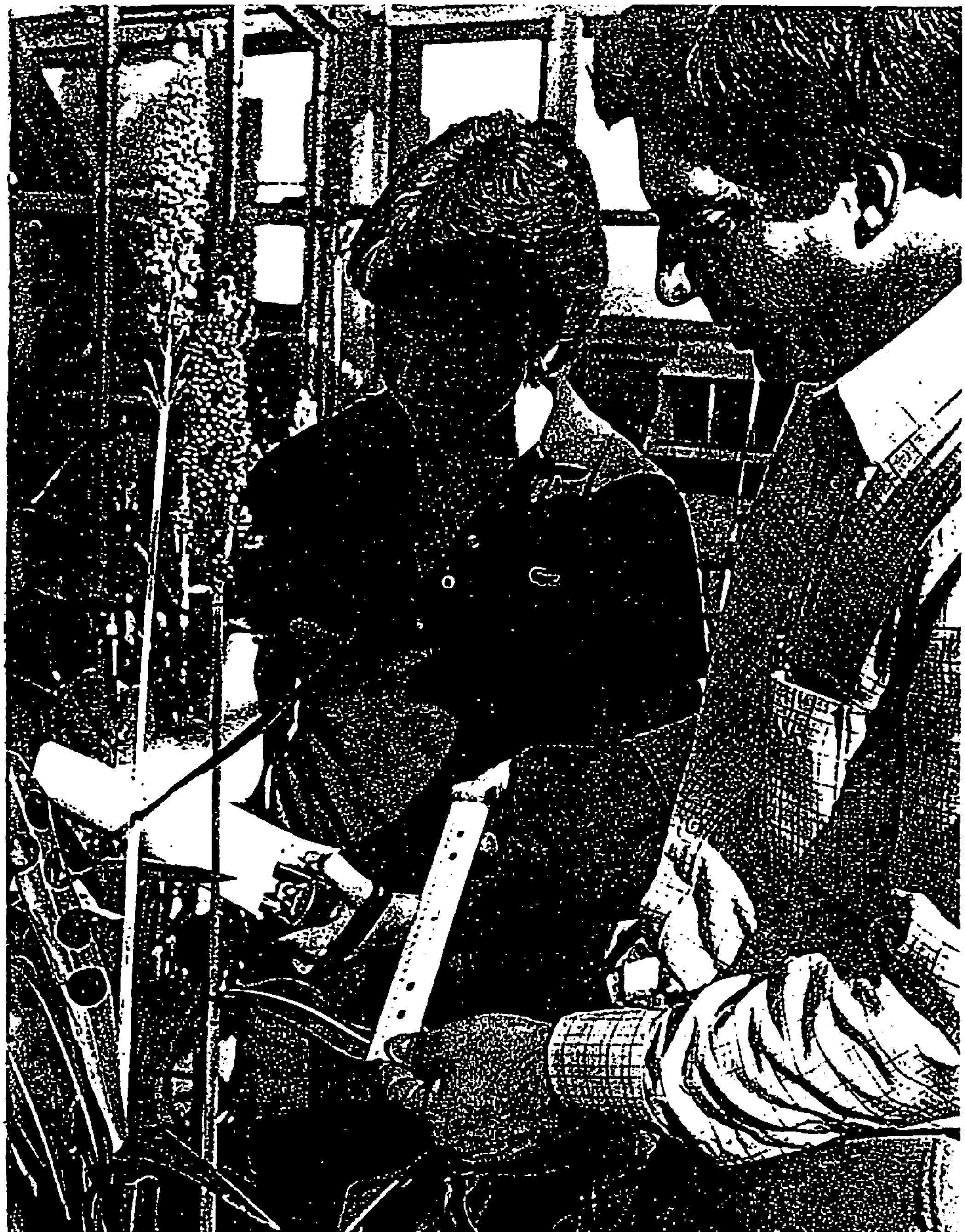
Because the relationship between erosion and soil productivity is so complex, in the past most of the research to quantify erosion's impact on soil productivity has focused on individual processes or on case-by-case studies for a specific crop or region. Because of problems with climatic variability, such field research was long and tedious and often took several years, even decades, to complete.

Now computer technology is being used to link together all these fragmented pieces of knowledge in a computer model called EPIC (Erosion-Productivity Impact Calculator). EPIC brings together what researchers have found out about hydrology, erosion and sedimentation, livestock grazing, nutrient cycling, crop growth, tillage, soil properties, climate, pesticides, insects,



Top: Soil fertility under no-till farming is an important concern addressed by the EPIC model. Amid a field of grain sorghum stubble, ARS engineering technician Larry Bartek extracts a sample core of soil for nutrient analysis. The tractor driven by Texas A&M student worker William Seavy provides power for the coring machine. (0183X44-20)

Above: To verify the effects on minimum tillage as they relate to the soil moisture component of EPIC. Bartek holds up a neutron probe that can measure soil moisture to a depth of over 6 feet. (0183X040-2A)



Above: Among the operations most critical to the success of EPIC is the continuous verification of its accuracy. In the course of conducting their own research, field scientists in ARS and at State Experiment Stations around the country often supply the data necessary to test EPIC against actual soil and crop conditions. Contributing to this voluntary and informal partnership with EPIC model makers are Texas Agricultural Experiment Station agronomist Tommy Gerik and Texas A&M student worker Tricia Ferguson. Their leaf measurements help crop physiologists evaluate and adjust plant growth components of the EPIC program. (0183X037-17)

Above right: The EPIC program also simulates the economic impact of soil erosion on various aspects of crop productivity. As part of a cooperative study with ARS, agricultural economist Paul Dyke of USDA's Economic Research Service reviews grain-cost projections based on data entered by Texas A&M student Katie O'Dania. (0183X041-24)

diseases, and economics—a wealth of knowledge to tackle the erosion/productivity problem.

"We already had all the basic information such as soil descriptions and acreages in different crops in a national computer filing system that could be put together especially for applying EPIC. All we needed to do was to plug it into our computerized system," Williams says.

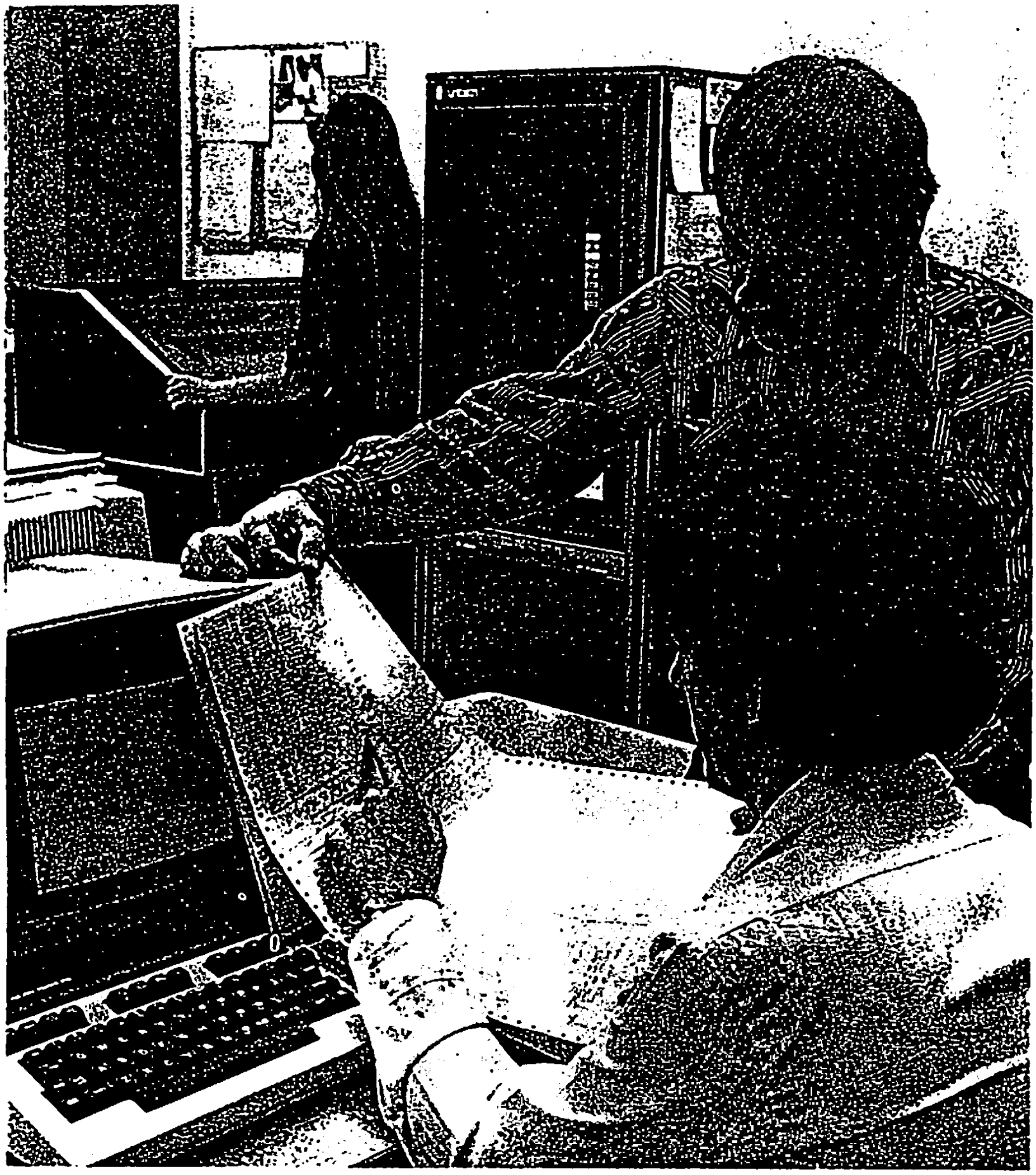
"Years of painstakingly difficult data gathering may finally pay off in providing new insights into how we can protect soil," says Terry B. Kinney, Jr., administrator of ARS.

"Once EPIC establishes the relationship between erosion and productivity, we will be better able to put a dollar value on the loss of U.S. soil," he says. "We will be able to select management strategies to maximize long-term crop production."

EPIC will provide information on the current status of soil and water resources in the United States—a Congressional mandate that must be met by 1985 as required by the Soil and Water Resources Conservation Act (RCA) of 1977. RCA assures that decisionmakers will have the tools needed to make informed, long-range policies concerning the use and protection of these resources.

"Because the problem is multifaceted, its solution must be multidisciplinary. EPIC is a 'supermodel' put together by some of our top scientists from many fields," Kinney says.

"EPIC will put together much of what we know about weather, crops,



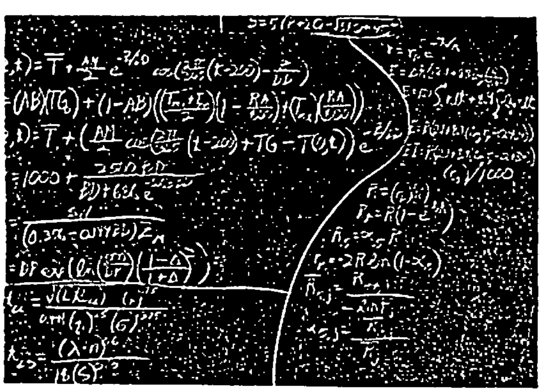
tillage, and soil characteristics and how they will affect U.S. crop production," says Williams.

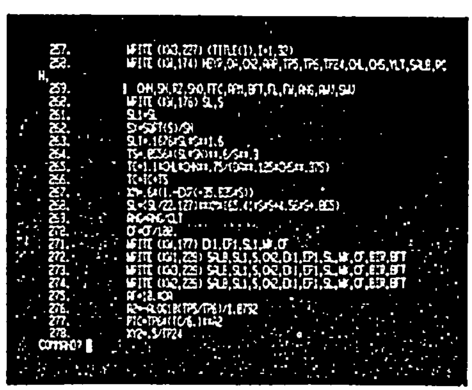
"Only through a multidisciplinary approach will the team members be able to pool their knowledge and use several already accepted methods to predict how the many causes of soil erosion—some controllable and some less controllable—will impact on future crop production," he adds.

Kinney says that EPIC supports Secretary of Agriculture Block's priority of determining why the Nation's rate of soil productivity has leveled off in recent years. "EPIC should be able to show what we can do to remedy the problem before it's too late," he states.

Now that testing of EPIC by the researchers is completed, the working model has been turned over to USDA's Soil Conservation Service soil scientists who are helping to evaluate the model so they can prepare the 1985 RCA assessment.

"Hopefully, EPIC will assist USDA by providing and identifying the productivity and conservation research needed to ensure that the United States will be able to continue producing food and fiber—for Americans and for the starving millions of the world—while maintaining our own natural resources and ensuring their value for future generations," says Kenneth G. Renard, research





EPIC's Many Parts

EPIC stores millions of pieces of information obtained from real-life measurements of erosion, sedimentation, hydrology, livestock grazing, nutrient cycling, crop growth, tillage, soil properties, climate, pesticides, insects, diseases, and economics. By recalling these data, Epic can accurately simulate the changing levels of soil, water, and nutrients that occur in nature.

By integrating actual and simulated data, EPIC models the complex relationship of soil erosion to productivity. The plant-growth model calculates po-

Far left: A printout from ALMANAC is reviewed by Texas Agricultural Experiment Station processing technician Dan Taylor (foreground) and ARS hydraulic engineer Jimmy Williams. Still under development, ALMANAC (Agricultural Land Management Alternatives with Numerical Assessment Criteria) is a comprehensive computer simulation model of agricultural production and the environment. It will eventually incorporate several smaller models, including EPIC. (0183X040-14A)

Below, left and right: Mathematical models describing just one specific component of nature can involve hundreds of letters, numbers, and symbols in complex chains that require years to develop. Without computers, some equations might take years to formulate. The blackboard model for soil erosion contains the significant variables for 1 day and 1 acre of land. (PN-7032) The computer screen displays part of the 2,700-line program that will handle the complete model. In less than 1 second, EPIC can use that program to predict how much soil will be lost on 1 acre in 1 year. (0283X079-3)

Left: Gathering more input for the EPIC model, computer programmer Dee Allen Wright records the latest data from an automatic weather station near an EPIC test plot in Temple, Tex. EPIC uses daily accounts of solar radiation, wind speed, maximum and minimum temperatures, and rainfall to simulate the effects of weather on soil erosion and crop production. (0183X042-12)

leader at ARS's Southwest Rangeland Watershed Research Center, Tucson, Ariz., and national technical advisor for soil erosion and productivity.

Renard continues, "Not until we know how changes in managing soils affect their productivity will researchers be able to select the best ways of managing soils to maximize their ability to continue producing crops over the long term."

EPIC has eight working elements—hydrology, weather, erosion, nutrients, plant growth, soil temperature, tillage, and economics—with 49 subparts which will allow simulation of individual situations for any area of the U.S.

Although some elements of EPIC—like the hydrology and erosion elements—are based on accepted technology, others will need further extensive checking and rigorous testing.

"Once EPIC is in place, only a few cents each year in computer cost, could provide the information needed to save millions of dollars in lost crop production," Williams says.

Jimmy R. Williams is located at the Grasslands, Soil and Water Research Laboratory, P.O. Box 748, Temple, Tex. 76501. Kenneth G. Renard is located at the Southwest Rangeland Watershed Research Center, 442 E. Seventh Ave., Tucson, Ariz. 85705.—(By Henry Becker III, Beltsville, Md.) ■

tential plant growth each day for the 10 major U.S. crops—corn, grain sorghum, wheat, barley, oats, rice, soybeans, alfalfa, cotton, and grasses. It simulates how much energy, water, and nutrients these crops use to grow roots, aboveground biomass, and seed. The model even simulates stresses—water, nutrients, and temperature—that limit plant growth.

Because plant residue management also affects erosion, any model designed to find out how erosion affects soil productivity must be sensitive to the tillage practices that control where crop residue accumulates on or within the soil. The EPIC tillage model simulates row height, surface roughness, and the mixing of soil layers, nutrients, and plant residues by any tillage operation for all 10 crops.

Several submodels keep soil residue information current. Equipment lists show how much residue goes into the plow layer when a farmer uses a particular piece of tillage equipment. EPIC keeps tabs on the relationship between surface residue and weather so it can identify those seasons when the soil is especially vulnerable to erosion. It will even predict how residue decomposition will affect the availability of nitrogen for plant growth, including the effect of soil microbes that tie up available nitrogen and release it later.

EPIC is generally applicable and efficient and can predict what effects changing ways of managing soil will have on water and evapotranspiration losses, nutrient and soil losses, crop yields, and the dollar values of practices needed to obtain these yields. All these predictions can be computed daily, monthly, or annually at a computer cost of only 15¢ per year of simulation on an AMDAHL 470 computer. ■

What Roles Do Forage Crops Play?

Doubtful oil reserves and supplies . . . rising fuel costs . . . pressures to reduce the farm cost-price squeeze . . . and, most important, an urgent need to preserve this Nation's resource legacy, soil and water.

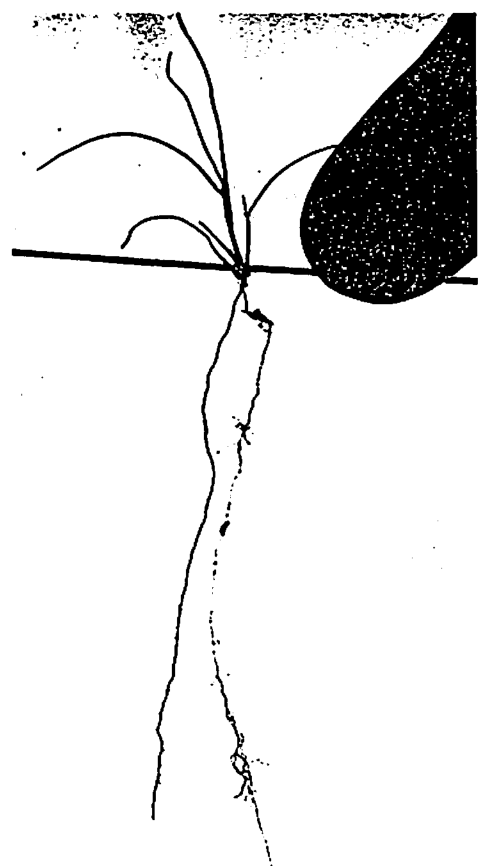
These are real forces causing U.S. farmers, ranchers, and agricultural scientists to reevaluate forage crops—grasses and legumes—and the agronomic practices that affect them. When managed properly, forage pasture and range plants do more to preserve soil and water and maintain soil productivity than any other crops, says Gerald E. Carlson, ARS's program leader for forage and range research.

Producers and researchers know that dairy cattle and meat animals can convert forages to food products on land that is often highly erodible and not suitable to many cultivated food and feed crops, he continues. This conversion not only produces food, otherwise unavailable, but also reduces loss of soil through erosion that now averages 5 tons an acre or more annually on much U.S. cropland.

They realize that production of forages, particularly legume forages and range grasses, may require less fuel and fertilizer, two costly ingredients of production, than other U.S. crops, Carlson says. They know also that bacteria on the roots of legume forages convert nitrogen from the soil atmosphere to a form the legume plant can use, and that some of the nitrogen is carried over in the soil for ensuing crops in a planned rotation.

For these reasons, ARS scientists are improving forage pasture and range species through research, often in cooperation with State agricultural experiment stations. This is done largely through plant breeding and selection and such other practices as improving cropping systems, tillage and seeding methods, and nitrogen fixation. Here are a few representative examples from studies on major forage pasture and range crops during the 1970's and 1980's in various parts of the Nation:

• A vital step toward reestablishing blue grama grass on abandoned, semiarid land in the Great Plains has been taken by ARS plant physiologist A. M. Wilson, Fort Collins, Colo. A long-lived perennial, blue grama is one of the



Top: Forage crops have gained a new and critical importance to American agriculture by conserving precious soil and water resources while providing economical nutrition for meat animals and dairy cattle. (PN-7036)

Above: A blue grama plant shows healthy growth 10 months after being transplanted with a plastic bandoleer around its roots. Encasing the roots keeps them from drying out prematurely. With improved machinery, bandoleer packaging could become the preferred technique for transplanting blue grama seedlings on a massive scale. (PN-6827)

Right: Severe drought will prevent seedling roots (right) from sustaining the growth of blue grama grass, but elongated crown roots (left) might reach sufficient ground moisture at greater depths. (0974X1529-16) most important native range plant species in the Great Plains. Large acreages of blue grama have been plowed and abandoned and are now threatened by erosive forces of wind and water. Establishing a seeding of blue grama on these abandoned lands is difficult, particularly during frequent warm or hot, dry winds.

Besides breeding and selecting for improved overall drought resistance, Wilson has found progeny in his continuing basic research that develop elongated crown roots that can supply five times as much moisture to seedlings as do parental seed roots. He has, in addition, found superior progenies with seed roots that can take up 30 percent more water a day than those of predecessor seedlings. Descendants of these improved progenies ultimately will be much better equipped to become established forage stands, survive drought, and protect against soil erosion and water loss through runoff.

• Scientists also are improving methods of reestablishing range grasses, often including removal of competing brush and weeds as a first step. One of the most serious of these weeds is mesquite, a perennial thorny shrub that is widely established on overgrazed grassland in areas of the south central and southwestern United States. At Tucson, Ariz., and Las Cruces, N. Mex., ARS researchers Howard Morton and Carlton Herbel have shown that one step—precise use of herbicides—can reduce competition by mesquite and encourage growth of native forage grasses. Besides increasing feed for cattle, regrowth protects the soil from erosion and increases infiltration of water.

The impressions left by this imprinter-seeder will collect water to give forage seedings a better chance in the arid Southwest. (0277X174-29A)

• ARS engineer Victor L. Hauser, Temple, Tex., is testing three nontraditional methods of establishing grass in the southern Great Plains where rapid drying of surface soil is a major obstacle to germination and seedling growth. The first method, punch planting, places seeds in the bottom of open holes at a depth exceeding normal planting. Soil around the seed remains wetter longer than surface soil. The second method, planting germinated seeds, encourages quick emergence which avoids adverse effects of rapid drying of surface soil. The third is transplanting live plants grown and transported in plastic bandoleer-type strips.

All three of the new approaches for establishing grass proved better than conventional seeding during dry soil conditions. Hauser says planting germinated seeds may be the easiest and most economical method to use in the field at present. Both punch and bandoleer planting are limited by lack of satisfactory machinery for field planting.

• Soil scientist Robert M. Dixon, Tucson, Ariz., has designed and built an imprinter-seeder having potential for increasing the chances for establishing range grass seedings. The imprinter makes impressions in the soil that concentrate the limited water supply for better germination and growth of young seedling plants.

As an example of the unit's effectiveness, 500 acres of bulldozed land near Fort Huachuca, Ariz., was imprinter-seeded to weeping and Lehmann love-

ARS scientists at the University of Minnesota are field-testing experimental strains of alfalfa as an annual forage crop. (0877W875-30)

grass in July 1978. Eighteen months later, the imprinted acreage grew more than 2 tons of grass per acre compared with less than a sixth of a ton from broadcast-seeded land. Land so treated not only is back in production, it also is protected by grass, nature's best erosion-controlling cover.

• A team of Federal and State scientists at St. Paul, Minn., is redesigning alfalfa in basic research for use as an annual to enhance its value in crop rotations, potentially one of this Nation's best tools for maintaining soil productivity. Alfalfa was chosen, the scientists say, because it is the most widely grown U.S. forage legume, occupying nearly one-tenth of all U.S. cropland, and it is efficient in fixing nitrogen for plant use. The new alfalfa, expected to be available to growers in the late 1980's, also could be grown in some areas where land is now fallowed, plowed and left idle for a year. Such a vegetative cover would help prevent water and wind erosion of exposed land.

A major goal of the team is an alfalfa for use as an annual crop that, besides providing feed for livestock, will leave 150 pounds of nitrogen an acre for the following year's corn crop when plowed down. In limited field tests to date, the team has increased grain yields by 11 percent as a result of added nitrogen provided a corn crop following an experimental alfalfa grown as an annual. The team members include Donald K. Barnes, plant geneticist, Gary H. Heichel and Carroll P. Vance, plant physiologists, all of ARS, and Craig C. Sheaffer, University of Minnesota forage production scientist.

• Hardy new strains of African buffelgrass, now being developed by ARS scientists at College Station, Tex., could put new life into grasslands in Texas, Arizona, New Mexico, and southern sections of Oklahoma and California. Potential benefits of buffelgrass include nutritious forage for cattle, drought-resistance, control of water and wind erosion, and possible ground cover for stripmined areas.

In research led by plant geneticist Elixis C. Bashaw, the scientists are using 800 plant specimens of buffelgrass collected in South Africa in the late 1970's to breed new strains. Their goal is a strain that will withstand temperatures as low at 25°F on grasslands at elevations up to 1,000 feet. A buffelgrass strain, introduced in the early 1950's in Texas, now grows on the coastal prairie south of San Antonio. It also is grown widely in Mexico, but only at low altitudes.

• A team of scientists at Tifton, Ga., has developed a new hybrid bermudagrass, Tifton 44, that is so nutritious that, as a cattle feed, it could add millions of pounds of beef a year to the marketplace. Cattle eating Tifton 44 have averaged daily weight gains that are 10 percent higher than beef gains on Coastal bermudagrass, the most widely used productive pasture grass in the South.

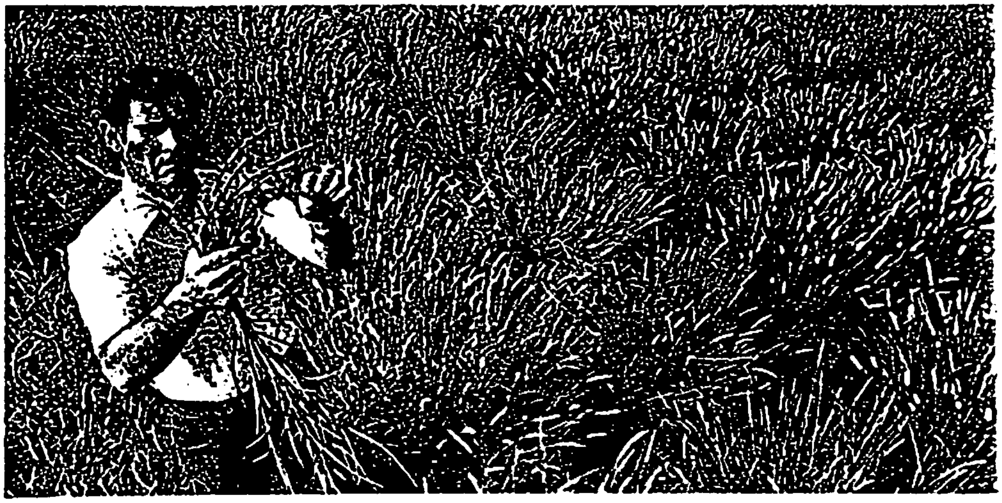
Tifton 44 is also more winterhardy

than Coastal and can be grown throughout a 500-mile strip of land running from the South Atlantic states to central Texas. Bermudagrass is a long-lived perennial with a vigorous spreading habit. It establishes a thick ground cover and has a root system that is noted for superior protection against losses of soil and water.

• Flintlock, an improved strain of western wheatgrass being established on the central Great Plains, is a relative newcomer. It is more drought tolerant and persistent than bromegrass for forage production and erosion control. Growers are finding it useful for conservation planting, dryland hay production, or vegetative cover on roadsides and in parks. It is also valuable for early season grazing before summer range grasses are ready. Developed by research agronomist K. P. Vogel, Lincoln, Nebr., Flintlock of lower elevations in the Central Plains latitudes, including western Kansas, Nebraska, and South Dakota, and eastern Colorado and Wyoming.

• Several million acres of rangeland have been overgrazed for 50 years in the northern Great Plains of the United States and the prairie provinces of Canada. Without grass cover, much of this land is subject to erosion by wind and water. Research led by Russell J. Lorenz, research agronomist, shows that native grasses can be brought back with nitrogen fertilizer. The scientists applied 40 pounds of actual nitrogen per acre for 2 years and realized a 30-percent increase in beef cattle carrying capacity and an additional 100 pounds of grain per animal by the end of the 10-year study. This management practice is now being adopted by ranchers in the Plains area.

• Reed canarygrass may move up on the forage popularity charts because of a new low-alkaloid strain soon to be available to growers. Gordon C. Marten, ARS agronomist, found in studies at St. Paul, Minn., that lambs grazing on MN-76, a new strain of reed canarygrass, averaged gains of 0.26 pound per day in two years of pasture tests. Lambs on Vantage and Rise, two older varieties, gained 0.18 pound and 0.15 pound per day, respectively. Reed canarygrass is widely adapted, particularly in the northern half of the United



Plant geneticist E.C. Bashaw seeks a strain of buffelgrass that will thrive on southern grasslands subject to periodic low winter temperatures. (1077A1450-36)

States, for wet pastures and for waterways. It also does well on upland soils. However, it has not been widely accepted by farmers because of its alkaloid content, low palatability, and problems with diarrhea. Only 3 percent of the lambs grazing MN-76 exhibited diarrhea in the 2-year pasture tests.

• Improved selections of the warm season grasses switchgrass and Caucasian bluestem can provide two to three times as much pasture per acre as cool season grasses from mid-June to September in the southern Corn Belt. State and Federal scientists in Missouri found that cattle gained 0.8 to 1.5 pounds daily during midsummer on the two grasses. Cattle often lose weight exceeding a pound a day during summer grazing slumps in mid-June to September. Both of the grasses are noted for erosion control; Caucasian bluestem is often used to stabilize earth structures and other critical areas subject to erosion.

• Scientists are determining more suitable cropping systems for legumes and breeding to improve legumes that are better adapted to acid soils so common to the Northeast. This includes birdsfoot trefoil, ladino clover, and red clover—all of which produce nitrogen from soil atmosphere to enhance plant growth.

Dairy scientists H. J. Larsen, University of Wisconsin, Madison, found trefoil-grass haylage (or silage) at least equal to alfalfa-grass haylage. Trefoil is grown on more than a million acres in the northeastern United States where soils are too wet for alfalfa. In the Wisconsin studies, dairy cows on the trefoil-grass haylage averaged 2.2 pounds more milk daily having 0.1 percent more butter fat. Some of the increase is attributed to higher grain intake by cows on the trefoil-grass haylage.

Agronomist Gordon C. Marten tested lambs on a pasture system including birdsfoot trefoil and found they gained 23 percent more than lambs on alfalfa-grass pasture. The increase in meat produced more than offset the lower lamb carrying capacity of an acre of trefoil.

Dairy nutritionist H. R. Conrad, Ohio State University, Wooster, found that ladino clover can make a good partner for alfalfa. Overseeded in alfalfa, ladino helped supply protein for lactating dairy cows. The nutritionist used rotational grazing to keep the forages in the vegetative stage and thus prevented them from going to seed. The pasture produced 1,600 pounds of crude protein per acre, and the cows averaged 50 pounds of 4-percent milk a day without supplemental protein.

Forage specialist R. R. Seaney, Cornell University, Ithaca, N.Y., says red clover has gained ground since the introduction of more persistent and disease-tolerant varieties: Arlington, Florex, and Redland, for example. They produce 1 year longer than older varieties, have bred-in resistance to northern anthracnose, and often will outperform alfalfa on poorly drained soils.—*(By Robert E. Enlow, Peoria, Ill.)* ■

Fewer Leaves Mean More Fruit

In the central part of the state of Washington, in the town of Wenatchee, a town that bills itself as the "Apple Capital of the World," something truly amazing is going on. Something that almost has to be seen to be believed. Apples and pears, fat and firm as they need ever be, are growing thick on rows of trees that look as if each had been pruned by the most meticulous of human hands.

Behind this sight not seen before is ARS plant physiologist Max W. Williams, and a growth-retarding chemical compound that is used experimentally to control grass growth for seed production. It has the proposed common name of Paclobutrazol, but currently is saddled with the undramatic designation of ICI pp333.

"Excessive foliage is the biggest problem faced by fruit producers all over the world," says Williams, who heads the research at ARS' Fruit Research Laboratory in Wenatchee. "Besides using energy that could be directed to fruit production, a thick canopy of leaves keeps the fruit from receiving sunlight and interferes with disease and insect control treatments."

For nearly 20 years, Williams has been seeking a means to reduce tree foliage production and increase fruit-producing efficiency. The adapting of ICI pp333 to fruit trees represents a significant breakthrough for his research.

"We are using chemicals to accomplish what genetics have so far failed to do," Williams says, "and for the first time ever, we can have control of an apple or pear tree's vegetative and fruit growth throughout the life of the tree."

The potential of ICI pp333 is enormous. Reduced foliage production not only means substantially greater fruit production, it also makes for a much easier harvest and, of course, sharply curtails the need for pruning, one of a grower's most costly operations.

Exposing fruiting spurs to more light enables more spur flowering to occur which results in more consistent annual fruit production. More sunlight also brings more uniform color to the fruit earlier in the growing season. Since the exposure is gradual, and water stress is at a minimum, little or no sunburn occurs.

Plant physiologists Max Williams (right) and Edward Stahly inspect the grapelike clusters of apples that have resulted from their research on pruning foliage using a chemical applied to the soil beneath the trees. (1082X1187-35)

The ability to control foliage and fruit growth could, Williams believes, enable trees to be planted as seedlings and eliminate the need for difficult to handle rootstocks.

Working with Williams on this project now are ARS plant physiologists J. Thomas Raese and Edward A. Stahly, and enthomologist Everett Burt with Washington State University, all at Wenatchee. In addition to Red and Golden Delicious apples, the researchers have successfully tested ICI pp333 on Granny Smith apples and Anjou pears and believe it will be useful on peaches and cherries as well.

Testing of ICI pp333 began in 1979. The compound was applied directly to the soil at rate of 2.5, 5, 10 and 20 grams of active chemical ingredients per 100 square feet of soil for each tree. The 20 gram rate has been effective for 3 years now, but is probably excessive. Lower application rates are now being tested.

No chemical residues have been found in the fruit so far: applying ICI pp333 to the soil seems to keep a safe distance between fruit and chemical. The researchers have been spraying ICI pp333 onto the soil beneath the trees, but Williams is trying band applications between tree rows.

Soil applications of ICI pp333 could eliminate the need for herbicide treatments in orchards by sufficiently retarding the growth of weeds and grass. Soil applications should also help prevent suckers from growing at the base of the trees.

Disease and insect problems might be abated by the use of ICI pp333 too, as tree leaves make good homes for many fungus diseases and insect pests. For example, in the ARS-WSU test orchards, untreated pear trees, infested with fruit-ruining pear psylla insects, stand next to treated trees absent of insect problems.

Nothing in this world has ever yet proven perfect and ICI pp333 is no exception. An overdose of the chemical compound can result in smaller, somewhat flattened fruit with short stems. Williams and his fellow researchers, however, have been able to easily compensate for this potential problem by adding either gibberellic acid and/or cytokinin before or at the time of full bloom. Addition of these chemicals increases fruit size, stem length and leaf size without increasing overall shoot production.

Williams guesses that it might be as long as 5 years before ICI pp333 is fully ready for commercial use. However, after spending 20 years in his search for such a breakthrough as ICI pp333, another 5 years is not too long to wait.

Williams and his co-workers are located at the Fruit Research Laboratory, 1104 North Western Avenue, Wenatchee, Wash. 98801.—(By Lynn Yarris, Oakland, Calif.) ■

Regulating Water Tables Benefits Yields, Slows Erosion

Southeastern Louisiana has annual rainfall in excess of 59 inches. This rainfall either permeates the soil or produces runoff. Too much infiltration may cause water tables to rise, thereby reducing crop yields by cutting off oxygen to the plant. Sediment carried by runoff can clog field drains, ditches, and channels. Pollutants present in the runoff can also contaminate streams and lakes.

Research by the ARS Soil and Water Management Research Unit at Baton Rouge, La., has produced a system that may counterbalance the area's heavy rainfall. Agricultural engineer Cade E. Carter and Louisiana State University assistant professor Richard L. Bengtson, in cooperation with the Louisiana Agricultural Experiment Station, have evaluated the potential of using subsurface drains to remove excess water from the soil during periods of high rainfall.

During 1980 and 1981, silage corn was grown on four field plots. Two of the plots were subsurfaced drained. Crop yields from the undrained plots were 4.59 tons per acre and 3.73 tons per acre (dry matter) for 1980 and 1981, respectively. Yields from the drained plots were 8.68 tons per acre and 6.48 tons per acre in 1980 and 1981, respectively, an increase of 89 and 74 percent (82 percent average) due to subsurface drainage.

For the period of August 1, 1980, to July 31, 1981, surface runoff was 14.7 inches for the undrained plots, and 12.2 inches for the drained plots, a 17-percent decrease due to subsurface drainage. Soil loss was 0.22 ton per acre from the undrained plots and 0.18 ton per acre from the drained plots, an 18-percent decrease due to subsurface drainage.

Cade E. Carter is located at the Soil and Water Management Research Unit, P.O. Drawer U, University Station, Baton Rouge, La. 70893. Richard L. Bengtson is located at Louisiana State University, Agricultural Engineering Bldg., Rm. 177, Baton Rouge, La. 70803.—(By Neal Duncan, New Orleans, La.) ■

Unlocking the Secret of Herbicide-Tolerant Seeds

The secret behind alfalfa seed's remarkable tolerance of the herbicide EPTC has been unlocked and practical methods for planting seed and EPTC in a single operation are now being developed.

Two years ago, ARS agronomist Jean H. Dawson, Prosser, Wash., found that EPTC, which is commonly used to control weeds in new seedings of alfalfa, could be applied directly to alfalfa seed without harming them. And he found that direct application provided a spectacular selectivity between weed and crop never before suspected. Dawson's technique not only provided excellent weed control, it also saved time, energy, and money, and lent itself well to erosion-controlling minimum tillage—using less chemical than conventional treatments.

Apparently, no one had ever thought of applying EPTC directly to the seed before because it was presumed that the herbicide would kill the seed. Dawson's research showed that the technique could work, but why the herbicide did not kill the alfalfa seed or seedlings was not known.

Dawson's latest research has revealed that alfalfa seedlings are not susceptible at all to EPTC until after emergence. Despite exposure to doses of EPTC 250 times that received in a conventional treatment, nongerminated alfalfa seed remains virtually immune to herbicide injury. Even after emergence, alfalfa is still highly tolerant to EPTC, and by that time the herbicide, through rapid diffusion into the soil, has diluted itself and is no longer present in such massive concentrations. On the other hand, weeds, especially grasses, emerge right into the teeth of concentrated EPTC and, with little tolerance to the herbicide, do not survive.

Dawson applied EPTC to commercial lime-coated alfalfa seed at concentrations of 2 and 4 pounds per acre. He then seeded the experimental fields at a rate of 22 pounds of seed per acre, and attained nearly 100 percent weed and grass control in the alfalfa rows. Such concentrations of EPTC on the seed resulted in initial rates of 500 and 1,000 pounds of EPTC per acre in the soil around the seed.

Planting herbicide-coated seed reduces the number of steps an alfalfa grower must perform to plant the crop and control weeds to a single-run operation. Also, dramatically increasing the efficiency of EPTC saves spending money and effort to seek and register new, stronger herbicides.

Perhaps the most important potential benefit of herbicide-coated seed is its application in minimum-tillage operations. Such operations are badly needed in some parts of the country to control erosion, but they are limited because of inadequate weed control.

Dawson is now evaluating plantings of alfalfa seed that has been mixed with formulated granules of EPTC both larger and smaller than the seed. The smaller granules are already commercially available and only a few modifications of conventional seeding equipment are needed for use on fields. Neither the larger granules nor the EPTC-treated seeds are on the commercial market yet.

Herbicide-coated seed should also work on field and snap beans and Dawson believes the method could be developed for use on other crops as well.

Jean H. Dawson is located at the Irrigated Agriculture Research and Extension Center, P.O. Box 30, Prosser, Wash. 99350.—(By Lynn Yarris, Oakland, Calif.) ■

Low-Nitrogen Cotton Resists Drought

Reduced levels of nitrogen fertilizer can make cotton plants more resistant to drought. This means less nitrogen should be applied to cotton in the dryland areas of west Texas and Oklahoma, than to cotton in the irrigated west.

Plant physiologists John W. Radin and Jack R. Mauney recently identified three basic responses of cotton plants to low nitrogen fertility: decreased photosynthetic rate; decreased ability to transport water from the soil to the leaves; and increased sensitivity of stomates (leaf pores) to water stress.

What those responses cause in cotton is slower growth and smaller leaves, increased earliness, greater boll shedding percentage, and increased drought resistance.

The increase in drought resistance prompted the scientists to study the effects on cotton of a more precise nitrogen management program.

Stomates, among other things, govern the amount of water being transpired from the plant. In nitrogen-deficient plants, the stomates start closing at the least hint of water stress, even when the leaves are not close to wilting. Because carbon dioxide for photosynthesis must also pass through the stomates, this conversion of plants into "water savers" occurs at the expense of photosynthetic production.

The result is a tradeoff—reduced yield potential in exchange for greater survival during drought—that may be most favorable in dryland areas where water is the greatest limitation to yield.

The importance of this altered stomatal reaction to water stress cannot be overemphasized, according to Radin and Mauney, The "water-saving" plants tend to meter out the available water relatively slowly, thereby prolonging survival considerably after the onset of drought. Furthermore, the slower development of soil moisture stress allows the roots to explore the soil more fully for stored water. Thus the trait would seem to have some survival value when water supply is limiting or irregular.

The problem for the agronomist or plant breeder who wants to improve varieties is to add just enough nitrogen

Plant physiologist John Radin compares transpiration rates in nitrogen-stressed plants with control (nonstressed) plants. (982X1067-23A)

Depending on water availability, heavy applications of nitrogen fertilizer may be beneficial or harmful to the overall economy of cotton production. The larger leaf reflects increased plant growth due to additional nitrogen in its system, but the smaller leaf will have greater drought survival. (0982X1066-11)

to support yield, yet retain the benefits of low nitrogen on plant efficiency and drought avoidance. It may even be possible to select for enhancement of individual characters of the nitrogen stress syndrome, say the scientists.

Altered cultural practices might also improve the suitability of the cotton plant for its environment. It seems logical that late applications of nitrogen—starting at perhaps first flower—might partially separate the positive effects of nitrogen on yield from the negative effects on drought resistance.

It has been found that late or split applications tend to increase yields even though plant size, number of flowers, and number of bolls tend to be slightly less.

Recent emphasis on water conservation by withholding irrigation water during vegetative growth would make timing of nitrogen applications even more critical than previously suggested.

A movement toward short season cotton as part of an integrated pest management program would also emphasize the need for efficiency in the early fruiting period. Other approaches to promoting drought resistance through the use of slow-release fertilizers, combinations of conventional and slow-release fertilizers, or even foliar fertilization still need to be explored.

John W. Radin and Jack R. Mauney are located at the Western Cotton Research Laboratory, 4135 E. Broadway Rd., Phoenix, Ariz. 85040.—(By Paul Dean, Oakland, Calif.) ■

Controlling Weeds in Narrow-Row Cotton

Until present day cotton tillage equipment is modified to accommodate a narrow-row system, growers may have to rely heavily on preplant herbicides to contain weeds.

Agronomist John H. Miller, Shafter, Calif., who conducted 16 experiments over a 4-year period, found that weeds could probably be controlled chemically because "herbicide performance was not greatly different from that expected in cotton grown in standard-row widths."

Narrow-row cotton, heralded by many cotton researchers and growers as having several advantages over the standard method—it uses sunlight more efficiently, among other things—is grown in rows from 10 to 20 inches apart. Standard widths are from 38 to 40 inches. Most equipment is manufactured to accommodate the wider rows.

In the study, Miller found that preplant herbicides could be effectively incorporated in soil with several tillage implements without loss of herbicide effectiveness. The equipment he used to incorporate the preplant herbicides after they had been broadcast-sprayed on the field included a spike-toothed harrow, a disk harrow, and a broadcast-type rolling cultivator. He also incorporated some herbicides with sprinklers. Combinations of several broadleaf herbicides with a grass herbicide applied before planting did not influence cotton stand or yield.

Miller's research also showed that tillage after crop emergence was less effective in the narrow-row cotton than in standard row widths, hence his suggestion that growers may have to place a great reliance on chemical weed control.

Flood irrigation compacts the soil surface of fine sandy loam soil, and postplanting tillage damages cotton plants by lifting the plants in the narrow rows.

Applications of herbicides to cotton that was about 8 inches tall injured the cotton and reduced yields about 18 percent below that of cotton with a preplant herbicide alone.

On a control plot where incorporation equipment was used but no herbicide was applied before the preplanting irrigation, the plots became heavily infested with annual grasses and cotton yields were reduced about 89 percent.

Additional information on the study can be had from the U.S. Cotton Research Station, 17053 Shafter Ave., Shafter, Calif. 93263.—*(By Paul Dean, Oakland, Calif.)* ■

Locoweed Poisoning In Cattle

Ten years of observations followed by clinical studies indicate that locoweed *(Oxytropis serecea)* poisoning in combination with high altitudes is a cause of congestive right heart failure in cattle.

"There is a predisposition to congestive right heart failure when cattle feed on locoweed at high altitudes," says Lynn F. James, animal scientist and research leader at ARS's Poisonous Plants Research Laboratory, Logan, Utah.

Congestive right heart failure in cattle is characterized primarily by a failure of the right side of the heart that causes an animal's brisket (lower chest) to swell. The disease occurs at elevations of 7,000 to 10,000 feet and incidence can be very high. Unless an afflicted animal is removed to a lower elevation, it will die.

It has long been believed that high elevations, where the thinner air places too much pressure on the vascular system of some cattle, particularly calves, were the sole cause of congestive right heart failure. However, young cattle grazing high altitude ranges infested with locoweed were observed to suffer an exceptionally high rate of right heart failure and this rate was highest during years when locoweed growth was heaviest.

As described by James, the symptoms include "gross lesions such as right ventricular hypertrophy and dilation, subcutaneous edema, hydrothorax, diarrhea and chronic passive congestion, and fibrosis of the liver.

"Microscopic examination of tissues collected from the same animals," said James, "revealed lesions of locoweed poisoning and lesions similar to the lesions of congestive right heart failure."

Cattle suffering from locoweed poisoning at elevations of 4,000 to 5,000

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feet display classic poisoning symptoms but no symptoms of congestive right heart failure.

James is continuing his work to verify the link between high altitude locoweed poisoning and congestive right heart failure and to search for what he believes might be "several additional causes" of congestive right heart failure.

Lynn F. James is located at the Poisonous Plants Research Laboratory, 1150 E. 14th N., Logan, Utah 84322.—(By Lynn Yarris, Oakland, Calif.) ■

Protecting Beans From Ozone

A chemical treatment to protect navy beans from ozone damage increased yields by an average of more than 20 percent in 3 years of tests in 12 separate experiments.

Beans are especially sensitive to ozone damage, called bronzing. Alfred W. Saettler, an ARS plant pathologist stationed at Michigan State University, says bronzing is a problem in navy bean production areas in Michigan and Ontario, Canada, usually late in summer. Symptoms begin with small lesions on the upper leaf surfaces which spread over the whole leaf, giving a burned or bronzed appearance. The leaves die quickly and this probably causes the yield reductions.

Saettler tested an experimental antioxidant chemical, EDU, made by the DuPont Company. He used both soil applications and sprays on several varieties and under a variety of soil and planting conditions on plots at East Lansing and Saginaw.

The average yield increases of treated over untreated plants of three varieties were: 16 percent for Seafarer; 20 percent for Tuscola; and 24.6 percent for Sanilac. In some tests bean yields were as much as 49 percent greater when plants were treated with EDU. Chemical treatment also increased snap bean pod production by 12 percent with Spurt, an ozone-sensitive snap bean variety, Saettler says.

The bronzing problem and associated yield losses depend on several factors, he says, including bean variety, soil moisture levels, stage of plant growth, production of ozone, and weather conditions. High ozone levels generally occur during hot, sunny weather. Ozone is formed when oxides in the air react with hydrocarbon emissions from burning petroleum.

The chemical is not being developed commercially, but appears very useful in assessing ozone effects on crop plants, Saettler emphasized.

The recent joint USDA-MSU release of two navy bean varieties, Swan Valley and Neptune, carrying resistance to bronzing damage, should help bean growers with the ozone problem, Saettler added. He worked with MSU plant breeders on the development of the new varieties.

Alfred W. Saettler is located at the Sugarbeets and Edible Legumes Research Laboratory, P.O. Box 1633, East Lansing, Mich. 48826.—(By Ray Pierce, Peoria, Ill.) ■

New Apple for Southeastern United States

ARS has released a new apple variety that is well adapted to the southeastern United States and other apple-growing regions.

Geneticist James M. Thompson selected the new variety, Blairmont, and tested it in Alabama, Georgia, Tennessee, New York, and Washington.

Blairmont has excellent color—dark red over pale yellow. Poor color is a problem with many apple varieties in the southeastern United States.

In addition to fine color, Blairmont has good fruit size (3-inch diameter) and good levels of resistance to locally important disease. It ripens early, about 112 days after full bloom, or 3 weeks before Red Delicious and just after Mollie's Delicious.

Blairmont blossoms have good frost tolerance.

Although the new apple variety produces large amounts of pollen, the blossoms are self-infertile and require pollinators. Thompson recommends Golden Delicious or Mollie's Delicious for pollination.

The trees of Blairmont are moderately vigorous and have a spreading shape. Blairmont has not been attacked by powdery mildew under field conditions. It has high levels of resistance to scab, fire blight, and bitter rot, and it is moderately resistant to black rot.

"Blairmont fills the need for a firm and attractive red apple for the Southeast. Its most undesirable characteristic is that the fruiting spurs of young trees tend to be long and limber. However, this tendency decreases as the tree ages," Thompson said.

Information and budwood may be obtained from James M. Thompson, Southeastern Fruit and Tree Nut Research Laboratory, P.O. Box 87, Byron, Ga. 31008-087.—*(By Bennett Carriere, New Orleans, La.)* ■