RZWQM—
Modeling Effects of Farm Decisions

A new computer model may soon help farmers and others better understand how their decisions on tillage method, timing and type of irrigation, pesticide and fertilizer applications, and selection of crop rotations affect the environment.

"The Root Zone Water Quality Model (RZWQM) was developed over the past decade by a national team of scientists," says Lajpat R. Ahuja. A soil scientist with the Agricultural Research Service, Ahuja coordinates the root zone water quality project and heads ARS' Great Plains Systems Research Unit at Fort Collins, Colorado.

"This simulation tool is needed to study the effects of management practices on soil water and movement of chemicals that may be hazardous to surface and groundwater quality," says Ahuja. "It's a model that integrates management practices with separate components dealing with hydrology, plant growth, nutrients, chemistry, and pesticides."

Actually, RZWQM is a series of compatible modules that can be attached or detached, as needed. Computer programmers term this flexibility "modular modeling." It allows developers to test new sections without having to rework any other portions. They say RZWQM could prove useful in many instances.

For example, major chemical companies ignore so-called minor-use pesticides because they do not want to spend money proving to the U.S. Environmental Protection Agency (EPA) that new compounds are safe. The cost of such testing would exceed the profits likely to come from sale of the products.

Chemical companies could use RZWQM to get a quick answer on which new compounds seem safe, then conduct field studies on only those most likely to gain EPA approval. One chemical company, Zeneca Ag Products of Wilmington, Delaware, has shown interest in using the model and assigned a scientist to work with ARS on the model's evaluation at Fort Collins.

"We hope that this model might be used in the future to replace actual experiments that involve root growth or water movement," says ARS rangeland scientist Jon D. Hanson.

"It could allow research agencies to concentrate scarce money on a few detailed projects aimed at gathering baseline data. No longer would they have to measure pesticide movements everywhere," he says. "If the water movement can be defined, the computer can figure out the rest. This reduces the need for expensive soil-weighing equipment and drainage solution samplers at many locations."

Farmers will also be aided by the model's best management practices mode.

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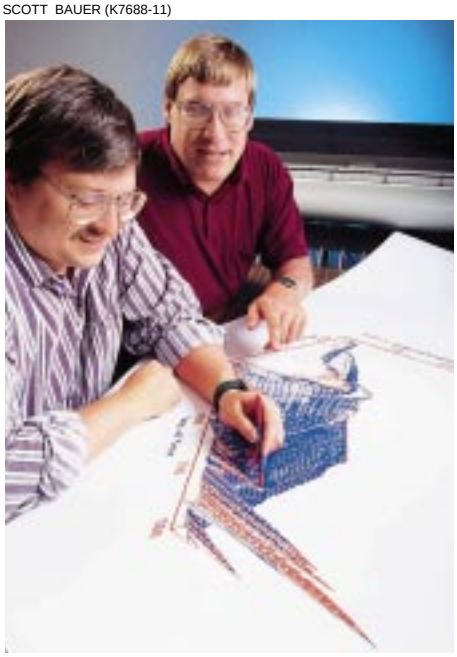

Computer specialist Ken Rojas (left) and range scientist Jon Hanson use the Root Zone Water Quality Model (RZWQM) to examine nitrate distribution in a simulated soil profile. The model enables scientists to forecast potential environmental pollution, such as from excessive nitrate leaching.

For example, if nitrogen movement to groundwater supplies is a potential problem in their area, they can discover whether it's better to plow in the fall or spring. RZWQM might show that a farmer should not apply all the nitrogen fertilizer at planting time, but instead apply it in two or three split applications.

Using nitrogen content—seen as greenness of the crop—provided by the model as a guide, farmers could also apply nitrogen with irrigation water when crops need the nutrient.

The model incorporates safeguards to ensure that the input data entered by users is within a reasonable range. If a range is exceeded, the model explains what it's looking for, or it instructs the user to refer to tables in the user guide.

ARS computer specialist Ken W. Rojas says, "The scope of science RZWQM covers is just mind boggling. Some scientists are using it to understand how the whole plant-soil-hydrologic system works."

"The model can run 20- to 30-year-long simulations of one field," says ARS soil scientist Marvin J. Shaffer. "These show how a monoculture or crop rotation would, under various fertilization rates, contribute to nitrate leaching and changes in soil organic matter content, soil microbial populations, and other indicators of soil quality."

And the Refinements Continue

Last summer, ARS agricultural engineer Hamid Farahani ran RZWQM to simulate no-till dryland corn production in eastern Colorado. He and co-researchers learned that it overpredicted yields on summit and sideslopes, while underpredicting them on lower areas. The researchers found this was because the model failed to accurately account for the amount of water that ran off upper areas onto lower portions of fields.

Current versions can now interpret this effect.

Gerald W. Buchleiter, an agricultural engineer in the ARS Water Management Research Unit at Fort Collins, tested RZWQM using data from a commercial farm in eastern Colorado. He found that the model's performance was acceptable as a research tool for predicting corn production on sandy soils under center pivot irrigation. After more testing, scientists will use RZWQM to estimate the effects of various farming practices on keeping fertilizers close to plant roots.

A larger test of the model was conducted in the Corn Belt. It was part of a regional study known as the Management Systems Evaluation Area project, a water-quality initiative involving research at 10 sites in Iowa, Minnesota, Missouri, Nebraska, and Ohio.

In Missouri, ARS scientists evaluated RZWQM to see how accurately it could predict crop yields, surface water runoff, and chemical movement through the soil profile.

"In general, the model was accurate in predicting corn and soybean yields, surface runoff, and chemical discharges in the runoff. But it underestimated the movement of chemicals downward through a soil that had a subsurface layer of high clay content," says soil scientist E. Eugene Alberts, who leads the ARS Cropping Systems and Water Quality Research Unit at Columbia, Missouri.

The scientists are now modifying the model to make it more accurate for soils encountered in their tests. It will then be able to predict formation of the cracks and fractures in high clay soils that permit more rapid chemical movement. Other sites where RZWQM is being run through its paces include Tifton, Georgia; Guelph, Ontario, Canada; Lisbon, Portugal; and Bonn, Germany.

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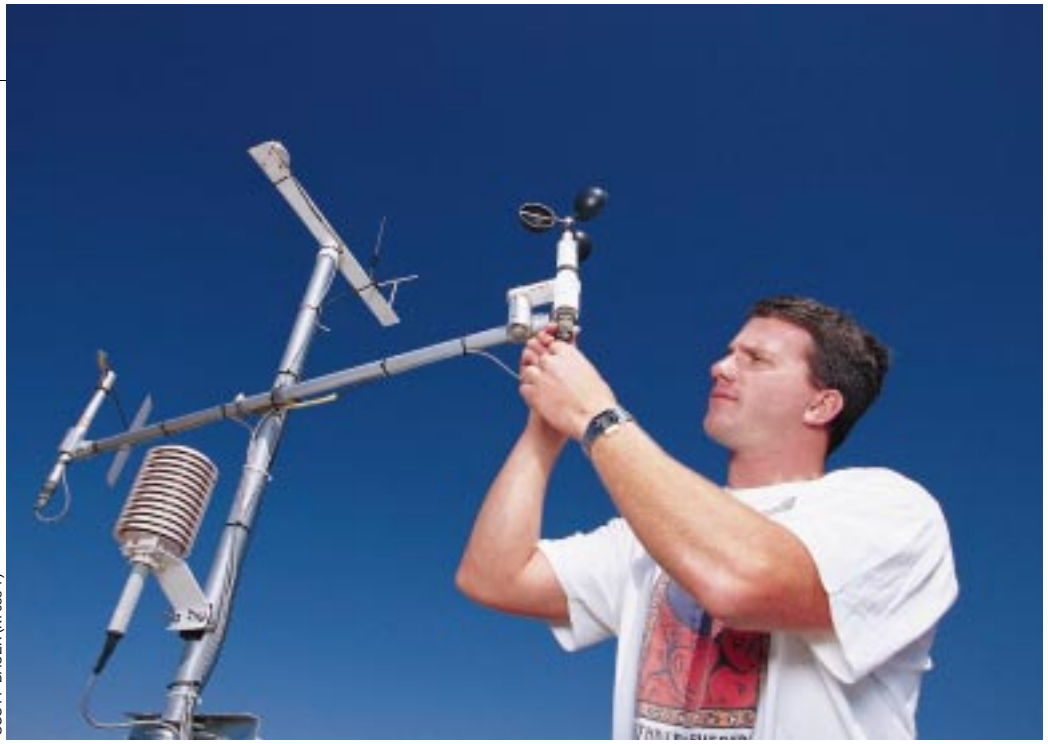

Data on rainfall intensities, solar radiation, minimum and maximum air temperatures, and windspeed gathered from weather stations maintained by technician Dan Palic are critical to the model's accuracy.

The next step is getting the program to users. So far, the scientists have trained more than 50 during 2- and 3-day sessions. And ARS has entered into a cooperative research and development agreement for the commercialization of RZWQM by Water Resources Publications, LLC. This Englewood, Colorado, company is now enhancing the manual so it is more user-friendly and will make it, the program documentation, and software package available to customers.—By **Dennis Senft,** ARS. **Linda Cooke,** ARS, contributed to this article.

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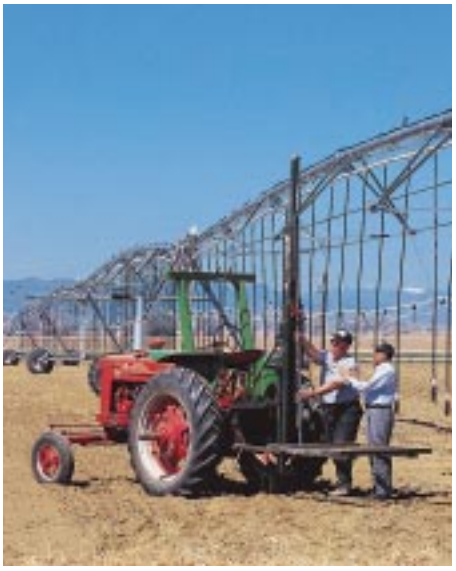

Soil core samples withdrawn from a field near Fort Collins, Colorado, by technician Mike Murphy (left) and soil scientist Laj Ahuja will yield information on soil horizons and their physical and chemical properties for the RZWQM model.