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Natural Resources Research Update

Title: **Uses of Computer Simulation Models in Ag-Research and Everyday Life**

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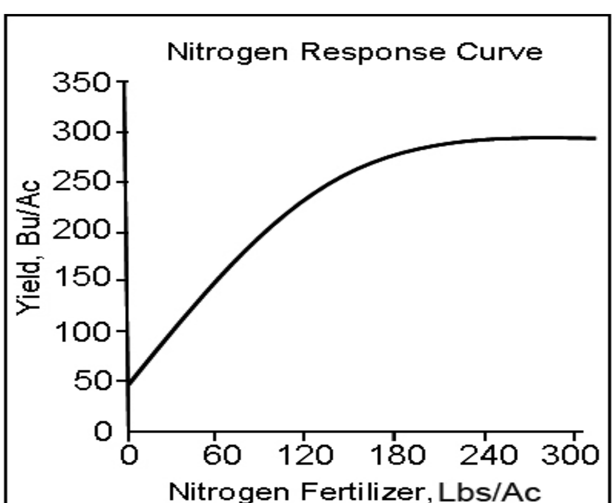
Summary: Computer simulation models are used daily by most people without knowing that they have used one. For example, computer simulation models are used by the National Weather Service to provide predictions of future weather. Agricultural scientists build and use computer simulation models to imitate natural systems such as plant and crop growth, and environmental consequences of management.

When the news media talks about models they could be talking about role models, fashion models, conceptual models like the auto industry uses, or computer simulation models. A computer simulation model is a computer code that attempts to imitate the processes and functions of certain systems. There are thousands of computer simulation models at work in the world today. Among other purposes, individual models predict weather, forecast economics of a nation, and project crop yield and quality.

Whether we realize it or not, we all use computer models to help us make decisions on a daily basis. Models we employ daily are those used by the National Weather Service to predict our local weather. We jokingly complain about the inaccuracy of the Weather Service's models but the fact is we make many decisions based on weather prediction.

Computer simulation models come in many different forms. The two most common forms are referred to as empirical models and process models. Empirical models are developed from measured data. A nitrogen study produces graphs of crop response to different levels of nitrogen fertilization (Fig. 1). The graphs can be reduced to equations like this:



$$Y = Y_0 + \Delta Y\left[1 - \exp(-cN)\right]$$

In the equation above, Y is the crop yield and N is nitrogen fertilizer input, and the other variables are the means by which the computer simulation model predicts crop yield.

This equation doesn't tell us why the different nitrogen levels affect crop growth. If you are only interested in the yield response and not the physical and chemical processes that are part of the nitrogen cycle, then an empirical model like this is satisfactory. The empirical model does not simulate the many interactions that nitrogen fertilization has within the soil/plant environment.

Figure 1. Crop yield increases with nitrogen (N) fertilizer application up to a maximum response.

Agricultural process models seek to provide greater understanding of the actions and interactions that take place within the soil-plant-atmosphere system as a crop matures. These interactions are often complex but by sub-dividing the whole system into smaller components, each individual process can be described. The whole system can then be "reconstructed" by re-linking the component processes.

One typical example is the water balance of a crop (Fig. 2). Precipitation (P) from rain or irrigation becomes separated in to various components such as run-off (R), soil evaporation (E), plant transpiration (T) and drainage (D).

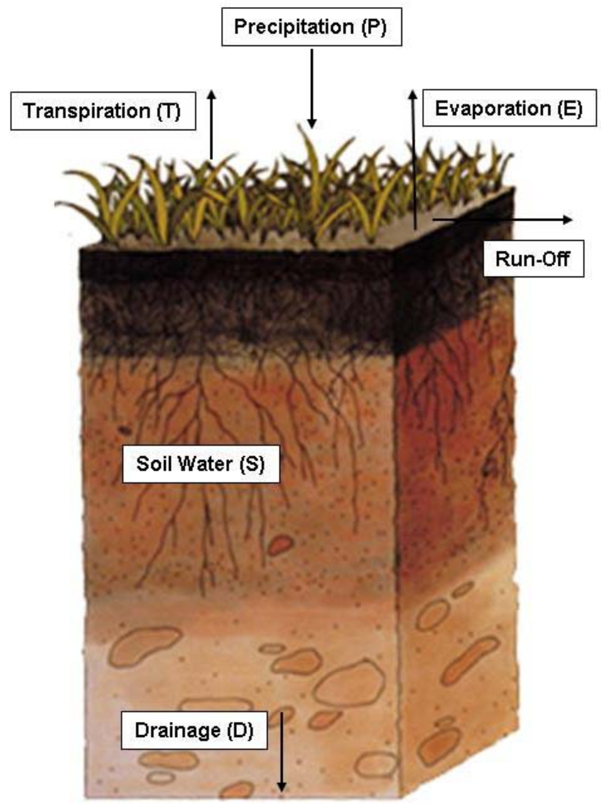


Fig. 2 Schematic diagram of the water balance processes.

These processes can be summarized in an equation for the change in soil-water storage:

$$\Delta S = P - E - T - R - D$$

Each component can be modeled to arrive at the net soil-water storage, which serves as the reservoir for uptake by plants. Mathematical equations are often more complex than this simple example, requiring careful formulation and fast computing to model agricultural systems over space and time.

Why should I care about models made by USDA-ARS scientists?

The advantage of models is that by attempting to understand the details of complex processes, management practices can be designed to influence these processes for a desired outcome. For example, crop residue retention on the surface under no-till or reduced tillage management reduces run-off and evaporation which increases infiltration and soil-water storage. Further, since drainage losses and water storage depend on soil texture, we can use simulation models to *predict* how a crop will respond to management changes, such as no-till, in different soil-climate environments. Agricultural models may also be used to extend experimental trials to a much broader range of conditions, including a particular field.

Models built and tested by the USDA-ARS estimate important things like how far pollutants travel, what crops will grow where, and the possible effects of global climate change. Two examples of agricultural systems models are GPFARM and the Root Zone Water Quality Model (RZWQM2) which simulate crop, forage and animal growth under different management and environmental conditions.

Bottom line**:** USDA-ARS models can be powerful tools for understanding and predicting crop and range responses to management in various environments.

Agricultural models are available for use by scientists, action agencies, farmers and ranchers, and agri-businesses. Several USDA-ARS computer simulation models are available online at:
(http://arsagsoftware.ars.usda.gov/agsoftware/).