Site-Specific Water, Nutrient and Pesticide Management

By C. R. Camp and E. J. Sadler

Site-specific crop management customizes fertilizer, pesticides, plant population and/or irrigation for the soil at a specific place in an agricultural field rather than applied uniformly.

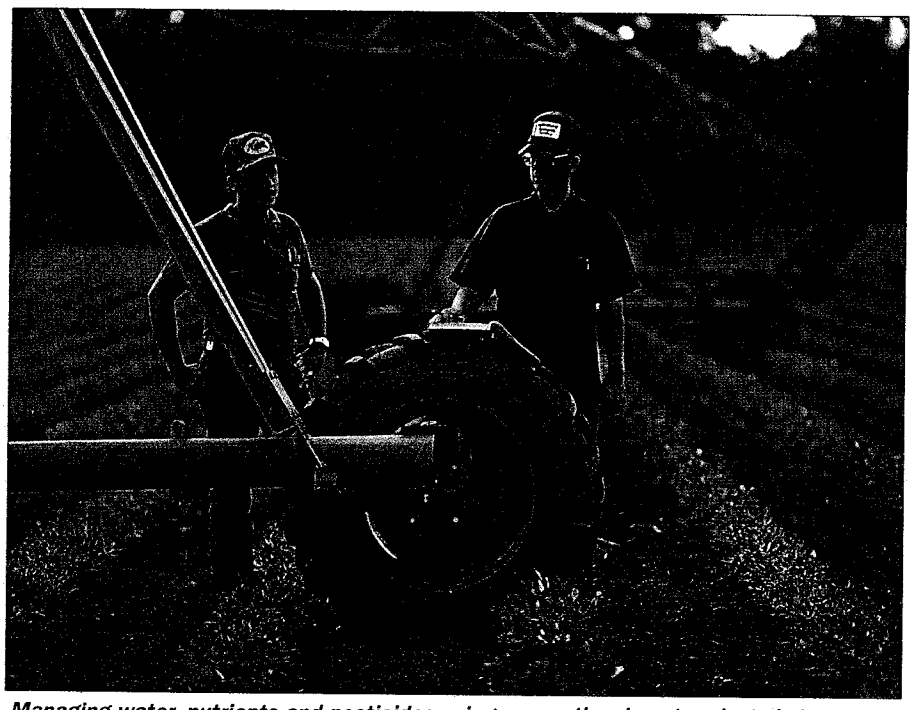
Site-specific or precision farming has been developed for spreading pre-plant fertilizer and for monitoring crop yields.

The site-specific application of irrigation water, nutrients and pesticides might offer additional opportunities to conserve water, to optimize nutrient use, to reduce the chance of either drought or flooding stress and to reduce potential fertilizer or pesticide leaching below the field.

Water, nutrients and pesticides are usually applied uniformly to entire fields under irrigation systems. Such uniform applications are usually based on average or most limited conditions for the crop. At places in fields with variable soils, materials are sometimes wasted and yields sometimes lost. Waste increases cost, and the possibility of environmental damage is caused by runoff or leaching through the soil profile.

Sources of variability, such as areas of sandy, clayey, compacted or rocky soils, can cause big differences in crop yield from place to place in the same field.

Managing water, nutrients and pesticides using conventional center pivots or linear-move irrigation systems is hampered by spatial variation. For instance, when irrigating according to soil water content, where in the field should it be measured? In almost every field, some areas need water earlier than average; others need it later. How far conditions deviate from optimum depends on the field's soil variation, which ranges from fairly uniform to quite variable among various regions of the country.



Managing water, nutrients and pesticides using conventional center pivots is hampered by spatial variation. File photo.

Variability is severe in the Coastal Plain region of the southeastern U.S., where field size is small with irregular boundaries, and most soils are sandy, have low fertility and store little water. Measurements and computer models have shown that crops in the Southeast Coastal Plain are particularly sensitive to differences in water available during the season.

Developing a System

In 1993, we started to develop an irrigation system that could better manage water, nutrients and pesticides on Coastal Plain soils. The general concept was to manage water and chemical applications to small areas within the total irrigation system area based on stored data, plant and soil measurements, or both.

Two commercial center pivot irrigation systems with computer-aided management were purchased. One was modified, in cooperation with University of Georgia at Tifton, to allow site-specific application of water and nutrients to areas approximately 30 ft. by 30 ft. To do this, additional sets of manifolds, valves and sprinklers were hung under the truss. Each set is 30 ft. long and includes three manifolds. Each manifold has nozzles sized to provide a different flow rate, and the three in a set are 1x, 2x, and 4x multiples of each other. By turning on one or more manifolds, seven application rates are possible for any given tower speed. This provides application depths up to 0.5 inch in 0.07-inch increments when the outer tower is moving at half speed.

Nitrogen is applied by injection into the water supply at the stationary base of the center pivot. Injection rates vary

with system water flow rate to achieve a constant chemical concentration.

Thus, chemical application is controlled by water application depth. The variable chemical injection rate is provided by a variable-speed, four-head pump, where the motor speed is controlled by a variable DC voltage. An onboard computer calculates the water flow rate and adjusts the motor speed to deliver the appropriate chemical volume to achieve constant concentration.

Water and nutrient applications are controlled by the computer system. It has a stored database and communicates by radio with the irrigation's trade-marked Computer-Aided Management System (CAMS).

The computer system is operated by specialized software written in the Visual Basic computer language. The first modifications of both hardware and software were installed early in 1995. For a test, the system was used to apply water and nitrogen to an experiment consisting of 144 small, individual plots.

Improvements in the control software and communication among components were made during 1995 and 1996. The management system was and continues to be developed under a Cooperative Research and Development Agreement with Valmont Industries, Valley, NE.

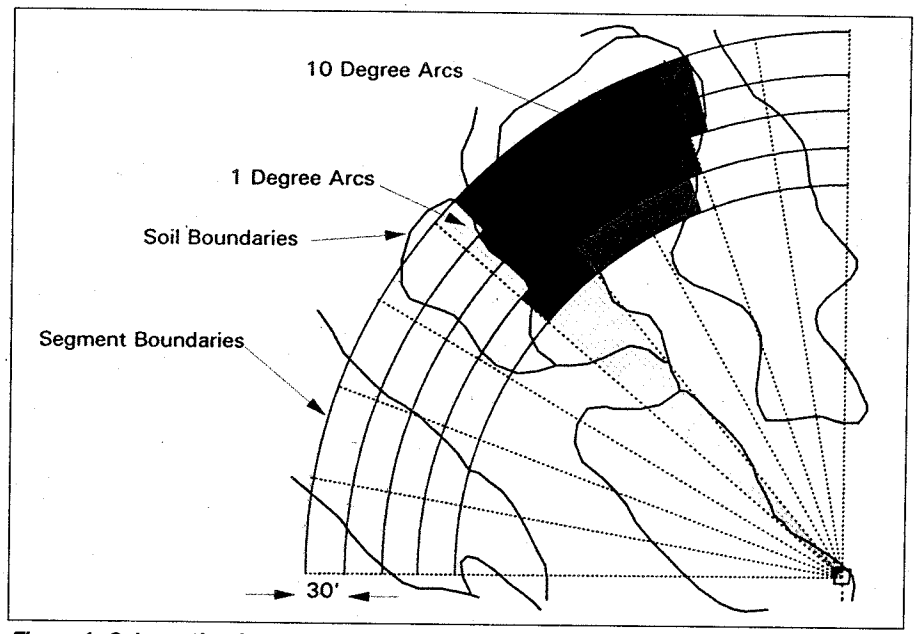


Figure 1. Schematic of soils with possible control zones identified. Irregular soil boundaries require more powerful control algorithms than do the regular plots in the experiment under pivot No. 1. The resolution shown is 1 degree of rotation.

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CENTER PIVOTS

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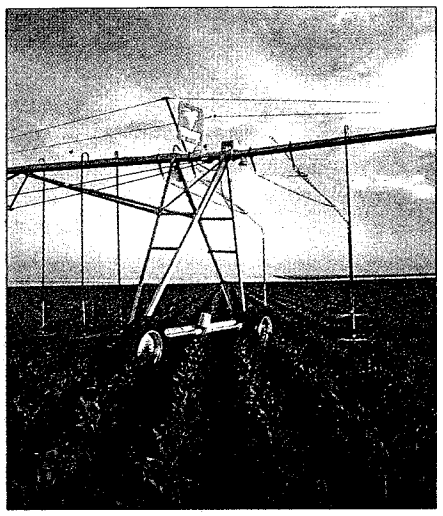
During summer 1996, a separate, proprietary low-volume pesticide delivery system was added to the center pivot. It was modified to allow control on the same 30-ft. segments as the water and fertilizer by adding routines to the system control software. Pesticides will be supplied to this separate system via a separate pump and tank that moves with the towers. For pesticides, the center pivot functions solely as a transport machine. Also in summer 1996, infrared thermometers were added to each segment, allowing feedback control of irrigation based on crop stress.



Commercial applications of the site-specific management system may require larger control elements. File photo.

We expect to continue refinements to the test system.

These experiences will guide modifications to a second center pivot. It is located on a highly variable soil for which long-term yield maps have been made. This second center pivot will be the culmination of the project — site-specific irrigation, fertilization and pest control on highly-variable soils with irregular boundaries, as shown schematically in Fig. 1. We will use combinations of independent control elements (30 ft. by 1-degree increments of the circle, minimum) to achieve optimum control for the irregularly-shaped areas. Commercial application of the concept may use larger control elements, depending primarily upon spatial variation and the economic and environmental benefits of variable-rate applications. ❑

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