POTENTIAL FOR VARIABLE WATER AND CHEMICAL APPLICATION

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COMPUTER CONTROLS FOR CENTER PIVOT/LINEAR

As consumer electronics have become computerized, agricultural equipment is also seeing computerization. Virtually all manufacturers of center pivot and linear move irrigation machines have offered computer controlled irrigation system panels for several years. These panels allow programming of sprinkler operations based on time, position in the field, or other conditions such as air temperature or wind speed. In addition, the presence of an on-board computer opens the way for as wide range of information processing to make intelligent irrigation decisions and control. For example, our first computer controlled prototypes automatically collected weather data, estimated crop water use, and made irrigation recommendations. They also interacted with the electrical power supplier to assist in managing electrical demand while protecting the crop from water stress.

New generations of these computer controls add increasing capabilities to monitor irrigation operation and control irrigations from the farm office, the pickup cab, or from virtually anywhere in the world. Each of these systems offers remote telemetry options, which may vary from a dealer-owned radio network to cellular telephone links or even satellite communication.

Over the past several years, our research group has operated under a Cooperative Research and Development Agreement with Valmont Industries to develop additional capabilities for irrigation and chemical management using the self-propelled sprinkler as a transport platform.

VARIABLE WATER APPLICATION

New sprinkler controls allow the irrigator to vary the application depth depending on rotational angle of a center pivot in the field. As we embrace the concepts of precision farming in the future, it may well become desirable to vary the amount of water applied along the pipeline to various shaped spots in the field. Non-productive areas, such as rock outcrops or seeps, need not be irrigated. Areas receiving precipitation from small convective storms need less water than those outside the storm path. Soils with low water holding capacity may need more irrigation than spots with heavy soils to carry the crop through until a rain. Computerization of sprinkler panels allows us great capabilities to irrigate in a manner never before practical.

Method of Changing Application

Most efforts at changing application amounts along the pipeline have been elaborate schemes to create water treatments to research plots. Two or more sets of sprinkler heads with different nozzle sizes can be installed on the machine, with appropriate controls to turn on one set, the other, both, or none according to water needs. Such a system has been patented in Idaho, and the patent has been licensed commercially.

A second method of variable application, which we have incorporated into a research unit at Fort Collins, uses a method which might be called pulse-width modulation. Sprinkler heads are controlled by solenoid valves, which are turned on and off over about a one minute cycle. The fraction of each minute that the head is on determines the fraction of full water output that is applied from that head.

Someday, it may be practical to modulate each sprinkler head by changing the nozzle size electronically to change the water application rate. Although such methodology exists today, it is cost prohibitive at this time.

Intensity of Control

Regardless of the method of controlling water application along the pipeline, the intensity of sprinkler control has significant impact on the cost of necessary wiring, plumbing, and computer power. On the one extreme, controls can be configured to operate each sprinkler head independently of the others. Although this provides the greatest flexibility for variable application, it is also undoubtedly the most expensive method. At the other extreme is an "all or none" control, which is achieved by the sprinkler in its standard configuration. The application depth is the same along the entire pipeline, and any variability is imposed in the direction of travel. An intermediate step, which we have incorporated into our control system at the ARDEC is to subdivide the sprinkler into a number of manifolds, each of which can be controlled independently. Current thinking is that segments of one-half to full tower span lengths will likely be practical for individual control.

A second issue is the number of increments of water application necessary to obtain benefit to variable application. In the beginning perhaps two levels, "on" and "off," will satisfy the most pressing needs to vary application (for example, avoid irrigating rock outcrops or seepage areas). With additional control complexity (but not necessarily more equipment), we could apply "high", "medium", and "low" amounts of water. Personally, I doubt that we will reach the point in the foreseeable future that we can quantify the difference in water needs for various places in the field to justify more than three or four different amounts of water application in a single field during a given irrigation.

Operator Interaction.

The ease with which the irrigator can implement variable management decisions will likely be a determining factor in the acceptance of such technology. At the present time, we have developed software for the base station of the Valley CAMS system to allow the irrigator to set up patterns of proportional water application. Prior to the irrigation, a map must be created to show areas of the field to receive more or less water, and decisions must be made about how many different application depths to apply and the size of areas to receive a given amount. Figure 1 shows such a map, for the linear sprinkler at ARDEC, under development.

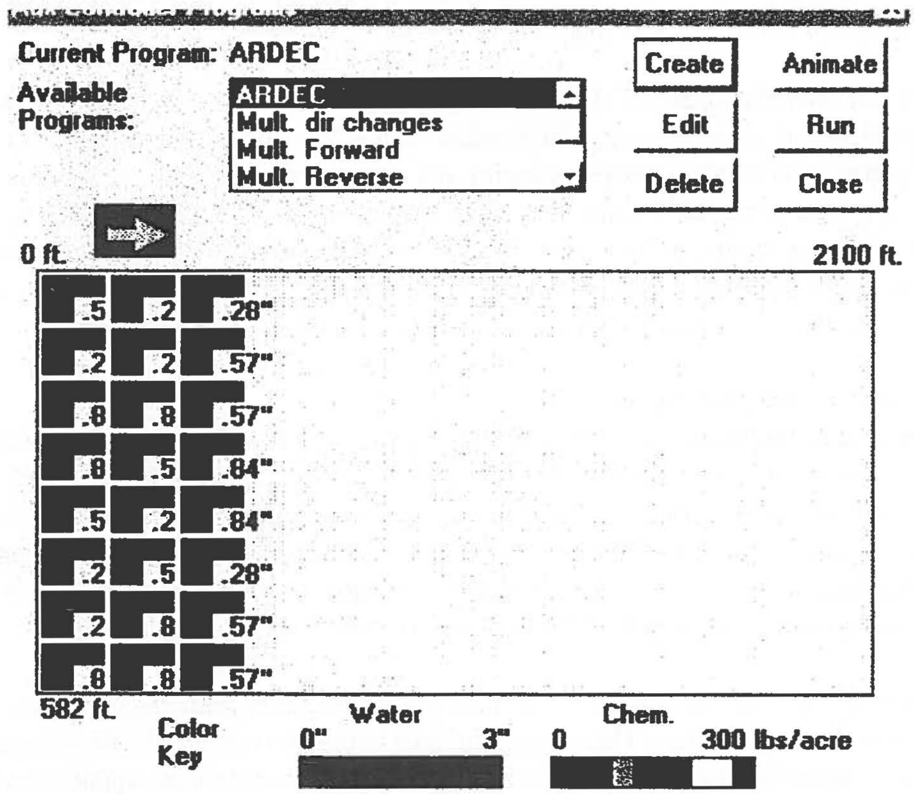

Figure 1. Variable water application map partially created for a rectangular field.

Along with development of hardware to apply varied amounts of water, we and others are developing techniques to develop a more complete (and inexpensive) picture of how much water needs to be applied and where. Remote sensing techniques, whether by handheld instrument, aircraft, or eventually satellite, have promise to identify the amount of plant material present in a small area and its water needs.

The next step beyond remote sensing and development of maps of crop water need is the software to automatically translate that map into signals appropriate to tell the sprinkler control panel which heads to operate at what point in the field in order to apply the required amount of water.

VARIABLE CHEMICAL APPLICATION

Chemigation

Chemigation, or injection of agricultural chemicals into the irrigation stream, has been a common practice for two decades or more. Regulations on chemigation systems have been developed in most states to safeguard against contamination of the water supply in case of system failure, so that this technique is now considered a good management practice. Variable application via chemigation is presently limited primarily to systems which inject chemical at intermediate points in the pipeline to apply chemical at the periphery.

In conventional chemigation, there may be considerable time delay between when the chemical is injected and when it leaves the pipeline through a downstream sprinkler. Thus, variable application of chemicals means changing the concentration of chemical in the water and becomes very complicated. In addition, the potential exists for contamination of water supplies if certain components of the system fail. Most states have developed regulations to require certain protective equipment whenever chemigation is practiced. Further, use of pesticides for chemigation requires specific registration for that application method.

Irrigation System Transported Sprayers

Because of the limitations of chemigation systems, particularly to variable application, we have concentrated our efforts on utilization of separate systems, mounted on the sprinkler to transport them around the field. This is not a new concept, having been developed in Georgia some twenty years ago. That system, named PASS (pivot attached spray system), was a relatively high volume system (200+ gallons per acre), utilizing large orifice spray nozzles, and configured to spray only when the nearest wheel tower was moving.

A unique system developed for orchard irrigation (Intertec, Inc) has been adapted as a sprinkler attached spray system. This system utilizes injection molded plastic components to control cost. The individual heads are connected in banks to control the application along segments of the sprinkler pipeline. The amount applied is controlled by pulsing the discharge from the heads, with higher frequency pulses resulting in greater application amounts. The system is readily adjusted for height to control wind effects, and is capable of applying from about 3 gallons per acre to about 200 gallons per acre with high uniformity. Valmont announced commercial availability in Fall 1997. The commercial system does not yet have the capability of variable application along the pipeline. As for variability of water application discussed above, the system is presently pre-programmed by the irrigator to determine how much chemical is applied and where. Figure 2 shows a typical screen in the base station software in which the irrigator creates the application map for a field.

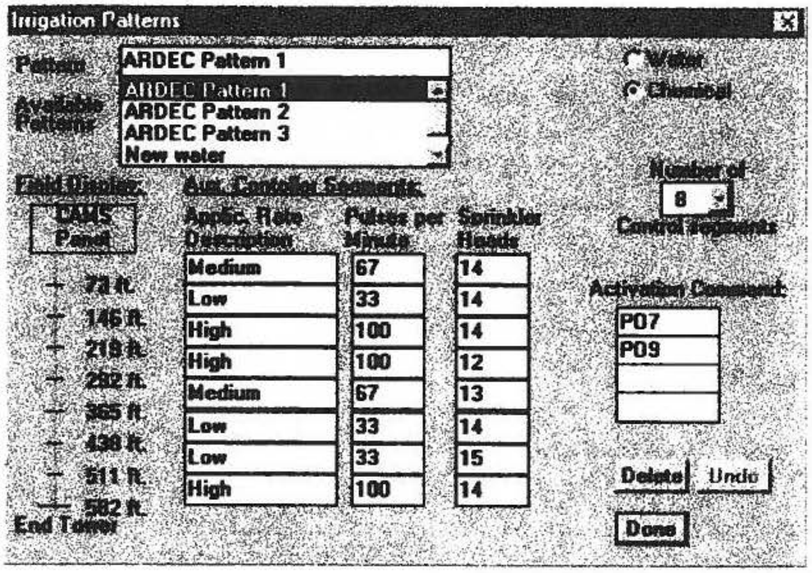

Figure 2. Setup for variable chemical application.