IRRIGATION SCHEDULING......AN ON-FARM UPDATE

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During earlier discussions of irrigation scheduling, we have talked about well capacity (gallons per minute) and relating this to inches per day that can be applied to a center pivot circle. Next, we discussed crop water use, also in inches per day, and how this water use varies with the climate and the stage of growth of the crop. Irrigation scheduling, then, is timing the frequency and amount of irrigation such that crop water use requirements are met, but not exceeded (runoff or deep percolation) taking into account daily changes in crop water use.

The method of irrigation scheduling used on our farm for about the last ten years was developed by Drs. Dale Heermann, Harold Duke, and Gerald Buchleiter of the USDA-ARS, Fort Collins, Colorado. This method calculates soil moisture depletion at the end of each day during the growing season by accounting for crop water use, irrigation amounts and rainfall, all on a computer program developed for a personal computer.

A weather station, owned and located on our farm, is used to take daily measurements of maximum and minimum temperature, wind, relative humidity, and solar radiation. These data are entered into the personal computer and a reference evapotranspiration is calculated, then converted into actual crop water use by applying a crop coefficient that takes into account that crop and stage of growth. Rainfall data is recorded for each field using a standard rain gage mounted near each center pivot field and entered on days when rainfall occurs. Irrigations are entered by putting into the computer, for each center pivot field, the time the irrigation passed over the starting point, and the amount of water applied in inches (knowing the pumping rate and speed of the pivot and applying to this an estimate of application efficiency). When the pivot passes over the ending point (360 degrees later in time), this time and amount applied are also entered.

Twice each week, we run a printout for each of our circles showing the actual soil moisture depletion for each circle, and how that depletion relates to the management limit of 50 % depletion in the root zone. We make the decision of whether to start, continue to run, or to stop each center pivot based on this information. The computer program also projects the crop water use for the next 10 days to give the manager an idea of what to expect over the entire farm. Three to four days later, after updating climate, rainfall, and irrigation data, the computer again prints an update, and management decisions are then updated for each circle.

This procedure has worked well, giving our farm employees a "feel" for the daily climate during the growing season and how daily changes in climate affect water use. Careful attention to the soil moisture depletion has yielded considerable water savings on each center pivot circle. However, all of the data collection required to do this method of irrigation scheduling requires at least 12 hours per week. Much of the interaction with the program requires technical interactions and judgment learned after years of experience. Therefore, in order to make this system more user friendly and to simplify the data collection, we began working with Underhill International Corporation in development of a radio control and data collection system that would utilize the irrigation scheduling methods developed by Heermann, et. al. mentioned earlier. This work was begun in 1994, and will be the subject of the remainder of this update. 1997 was the third year of use for this system, called by the trade name, "Pivot-Alert". Let's start by describing the radio control system. The system includes a base station module and antenna located at our farm office. This base station is connected to a personal computer. Although the control and monitoring features can be done by the base station as a stand-alone unit, the personal computer opens up capabilities for software involving display, data organization, the telephone, and interaction with the Pivot-Alert system by the operator. Next, there is a licensed radio repeater used to receive and transmit signals over a 40-50 mile radius. Finally, at each center pivot there is a radio receiver and antenna. The radio equipment is wired into the power supply and safety system within the center pivot panel box.

After using this radio control system, our farm has benefitted in several ways. We get to shut down pivots faster, since we see that color change on the display in the office or are notified by telephone when a pivot shuts down. During mid-summer in critical growth stages of the crop, this is very important. Before this control system, we would get into two pickups each morning and drive the entire route looking to see which pivots had turned off. Now we look at the display early in the morning, and by the time the employees arrive, we go to just the pivots needing attention, then focus later on the routine checking and maintenance of the rest of the pivots. A subtle benefit is that our employees appreciate fixing the flat tires, gear boxes, and major problems early in the day before the heat and humidity get severe. We have completely eliminated the second trip around the curcuit in late afternoon to check pivots, saving us labor and wear on vehicles. If we receive a significant rain, we shut the systems off at the computer instead of driving, often in the dark, on muddy pivot roads and township roads to reach pumping plants at each pivot. Pivots can be programmed from the computer in the office to shut off at a certain position or time of day. Finally, a regular or cellular phone can be used to interrogate or control center pivots during the time the operator is away from the computer system located, in our case , in the farm office.

In 1997, the irrigation scheduling module adapted from Heerman, et al, was added to the software, and we used this module in conjunction with our normal scheduling routine. The Pivot-Alert irrigation scheduling module inputs the data on the soil, well capacity, crop and related information very similar to our present irrigation scheduling program. Where they have made improvements, however, is in the handling of crop coefficients for corn, soybeans and alfalfa, and in the way the the user interacts with the scheduling information. Also, the climate data is more automated in that the computer calls a nearby weather station at 1 a.m. each day to get the climatic data for the previous day and enters this data automatically into the scheduling module.

The central problem in using crop coefficients is to match the crop coefficient curve with the way the crop is actually growing in the field. In our previous work with the Heermann, et al, computer program, judgment had to be used in establishing dates for root development date, effective cover date, and harvest. When abnormal growing seasons occurred, for example, a cold late spring with slow emergence, the dates had to be adjusted, which takes experience, in order to get the crop coefficient curves to match the actual crop growth. With the Pivot-Alert scheduling module, the manager must simply look at the crop, determine the stage of growth the crop is in, and input this stage of growth into the scheduling module. The only disadvantage to the new method is that, as the crop grows, the successive crop stages have to be input in a timely manner to keep the crop coefficients current with the growth of the crop. Nevertheless, estimating the crop stages is easier for new operators to master, and therefore a definite improvement in the technique of determining crop coefficients in the field.

Finally, regarding irrigation scheduling data output and interpretation. With the Heermann, et al, scheduling program, a printout is generated which gives the current soil moisture depletion for each field in numeric form. The program then forecasts water use for the next 10 days for each field and predicts when the 50% allowable depletion will be reached. The output is a "snapshot in time" of each field that must be updated in 3-4 days after the climatic data, rainfall, and irrigation data are input. The manager interprets these data to decide whether to or not to start, continue running, or stop each system. The Pivot-Alert scheduling module, first of all, collects the data on irrigation automatically, since irrigation amounts are logged in every time the center pivot passes a pre-selected control point based on the well capacity of the well supplying water to the center pivot. Effective rainfall still must be entered manually from rain gages placed adjacent to each circle. The module gets the climatic data automatically as mentioned above, and using the crop coefficient based on stage of growth, the crop water use is calculated internally.

Irrigation scheduling output for the Pivot-Alert module is in pictures rather than numbers. The manager looks at the color of that particular circle on the computer display monitor to see how close to 50 % depletion the circle is. For example, blue might be used to denote 0-10 % depletion, green for 11-40 % depletion, yellow (caution) for 41-50 % depletion, and red (possible crop injury) for depletions below 50 %. There is a "thermometer-type" indicator, as well, that shows the soil moisture status in the root zone. Each day, as water is used, the "thermometer" drops, indicating the circle is getting closer to 50 % depletion. An irrigation raises the "thermometer" line accordingly. All the while the whole circle is changing color in accordance with the preset color limits as soil moisture goes up or down. A second colored circle shows the status of the circle ahead in time just before the center pivot gets to the control point. This can be used to see if the current rotational speed of the center pivot is too slow or too fast. All of the data for the crop stage, well capacity, and evapotranspiration are also displayed conveniently on the same screen. Thus the irrigation manager studies the screen display for every center pivot each day or as required and visually determines if the pivot should be started, continue to run, or be stopped. We think this visual display concept is a big improvement that will allow irrigation scheduling to be mastered without as much experience and training.

Irrigation scheduling continues to be a high priority for our farming operation in the light of good stewardship and to demonstrate to all concerned that a diligent effort is being made to conserve our most valuable of natural resources, water. Technology offers much in improving the techniques in this effort, in particular radio control concepts.