Irrigation Management: Engineer's Perspective

H. C. (Lyle) Pringle, III

An irrigation demonstration project, funded by Cotton Incorporated (CI), was initiated in 2011 in Mississippi to access the usability of commercially available wireless soil moisture systems. Soil moisture sensors have been around for years, but adoption by producers has been almost non-existence in the mid-South, largely due to the amount of time and effort needed to collect a limited amount of data and process it into a usable product. The addition of electronic dataloggers allowed the collection of enough data that one could chart the drying of the soil between rains or irrigations as the crop uses the soil moisture or the wetting of the soil with rain or irrigation, a great improvement. Typically, data would be downloaded from the dataloggers once or twice a week, and then it would be transferred to a computer and put it into a chart and/or tabular form. Now, all the soil moisture sensor manufacturers are offering wireless solutions to send your data out of the field and into your computer or smart phone with associated software that will automatically put the data in chart and tabular form, greatly decreasing the time needed to obtain the data. For this to be accepted by producers, it will need to be user-friendly, fast, accurate, reliable, easily interpreted, and economical. CI has funded several demonstrations in the mid-South to access the functionality of these systems.

In 2011 an irrigation initiation demonstration was started on one of the Bush family farms near Greenwood, MS. The youngest son, Chris, agreed to this project because he was concerned about potential water regulations in the Mississippi Delta and he was concerned about water conservation on his farm. He was also interested in getting information on soil moisture remotely, especially on fields located farther away from his headquarters.

In this project, I partnered with Ken Fisher, USDA, Darrin Dodds, Mississippi Cotton Specialist and Jerry Singleton, Area Extension Agent. We agreed to install sensors, dataloggers, and wireless equipment in three different irrigation sets. Chris was asked to initiate irrigations in each of these three sets approximately a week apart if no rainfall occurred, starting the first set at the time he felt was proper. Once initiated, he was to determine the timing of subsequent irrigations to each set. As we collected soil sensor data, it was made available to all involved.

Decagon EC-5 soil water content sensors and a Decagon EM50G cellular datalogger were installed in the middle of each of the three irrigation sets. The dataloggers were placed in the drill within the canopy and below the height of the tool bar of cultivating and spray equipment. The sensors were placed at depths of 8, 16, and 24 inches in the drill. The dataloggers were set to collect data every 2 hours and to send data 4 times a day by cellular transmission to the Decagon server where data would be stored. The data would then be available for download on-line from this server to each participant's computer where it could be charted and summarized with Decagon's Data Trac software.

Watermark soil water potential (SWP) sensors were installed at the same depths and at all three sites for comparison. These sensors were connected to WatchDog dataloggers by Spectrum Technologies. This system was not wireless so data from each site was downloaded weekly with a data shuttle and then transferred to a computer with little to no problems. SpecWare 9 software was used to summarize the data in graphical and tabular form. The summarized data was shared with the producer weekly.

In 2012, the irrigation initiation demonstration was continued on Bush farms at a different location. Four different irrigation sets were instrumented. Chris was asked to initiate irrigations in each of these four sets approximately five days apart if no rainfall occurred. We consulted with Chris on when to start the first initiation and when to start back with subsequent irrigations on each set using the soil moisture readings.

We installed a new Irrometer wireless monitoring system with the Watermark soil water potential sensors in 2012 and the same Decagon sensors, dataloggers and wireless systems described above, that were used in 2011, in Chris Bush's fields near Money, MS. We selected an area in each of four irrigation sets that were more similar in soil type to each other than other areas. We installed three Irrometer monitoring sites in each of four different irrigation sets. These units were located ¼, ½, and ¾ the length of each run in each set. We installed one Decagon monitoring site in each of four different irrigation sets, located ½ the length of run ten rows over from the Irrometer monitoring sites. The Watermark sensors and the Decagon sensors were installed at depths of 8, 16, and 24 inches, and the Irrometer temperature sensor at 8 inch depth.

The Irrometer wireless system consisted of twelve 950T transmitter modules which radioed (900 MHz, range of 1500 feet) the data collected from the sensors (when there are changes in the data) to the 900R receiver module, where it was stored. Then the data was transferred to the 900M-CG cellular gateway by hardwire, where it was then sent to the Irrometer server as changes occur in the data. At the server, the data is put in tabular and graphical form and can be accessed with a username and password. All involved were given usernames and password and have been able to access the data with no problems.

The Irrometer 950T transmitter modules were modified slightly by adding an extension cable (LMR 195 coaxial cable with RSMA connectors) between the unit and its antenna, so the unit could be placed low enough in the drill to miss being damaged by tractors and their implements. The antenna was placed on the top of a six foot fiberglass pole that was flexible enough to not be damaged. The Irrometer 950R receiver module was located adjacent to the well and mounted on a tripod approximately 12 feet above ground, the Irrometer 900M-CG cellular gateway was mounted approximately 8 feet above ground on the tripod. The 950RG raingage and solar panel were also mounted on the tripod.

After having connectivity problems in 2011 with the Decagon EM50G wireless cellular dataloggers, we contacted Decagon Devices in mid-July. The service department was able to look at the history of the dataloggers' communications (strength of signal, cellular provider, etc.) with their server. It was apparent to them that the strength of cellular signals degraded over time, followed by the signal being dropped. They went back and looked at their records and determined that they had shipped the dataloggers with the wrong SIM cards for our area. They shipped the correct SIM cards with instructions on how to install them. Since installing these SIM cards, we have not had any more connectivity problems. Also, connectivity was never compromised due to the datalogger and antenna being located within the canopy.

In 2012, the Decagon wireless system has had some cellular connectivity problems on two of the four units. The signal strength was not considered very strong in the area. The AT&T tower was located approximately 5 miles to the West of this location and in sight over the tree line. Of the two that initially had connection problems, one started connecting and updating the data after two weeks. We tried moving the other unit above the canopy and approximately 6 feet in all directions to see if we could get a better signal without success. Making use of Decagon's utility program that can determine what the signal strength is at a location before you install your sensors would have helped avoid these connection problems. The datalogger for each unit worked well most of the time but there were some periods of time that no data was recorded on three of the dataloggers, possibly battery connection issues. Data was not recorded from a couple of the sensors for a few days due to connection problems.

The Irrometer wireless system performed well throughout most of the 2012 growing season. Five of twelve 950T transmitter modules needed some attention after 4.5 inches of rain fell the in mid-July. There were indications that moisture may have entered a couple of the enclosures, so silicon was put on all the enclosures where the extension antenna cable was attached. In two or three of the units it appeared that one of the batteries had popped out of the battery enclosure enough to not make contact. These were reinserted. After these corrections, we still had problems with two of the modules. One reported intermittently the rest of the growing season and one that did not report again. Further investigation will be needed to determine the cause. Following a rain event on August 13th transmission of the data to the Irrometer server was ceased. It appears that moisture entered the 900M-CG cellular gateway enclosure and affected the modem operation. The unit was sent back to Irrometer and they found that the unit had to be reprogrammed.

Chris provided a commercial John Deere round bale cotton picker to take a sample from each set. In 2011, the driver was instructed to pick until a round bale was completed. The round bale was weighed with a weigh trailer and measurements were taken to determine the area covered so the yield per acre could be calculated. A gin turnout of 38% was used to adjust seed cotton to lint yield. In 2012, a sample consisting of two round bales were harvested from each irrigation set.

Results from the Decagon EC-5 sensors in 2011, indicated that root activity appeared to be at all depths as evidenced by declining VWC% values. The magnitude of change at each depth suggests that less water was being removed from the 16 inch depth compared to the 8 inch depth, and even less water was being removed from the 24-inch depth as compared to the 16 inch depth. Not having much water removal at the 24-inch depth on a soil that should support a deep root system may be an indicator that the cotton was watered too much. At site 2, the soil was allowed to dry the longest since irrigations were initiated last. Higher magnitudes of change in sensor readings were observed at the deeper depths at this site at initiation, and the highest yield samples were collected (Table 1). Significant rainfall events following irrigations by one to three days may have reduced the effectiveness of these irrigations.

Likewise, over the season there appeared to be root activity at all depths as evidenced by declining SWP data from the Watermark sensors in 2011. At sites 1 and 3, the 8 inch depth had the most root activity. Sites 1 and 3 appeared to be over-watered because the SWP for deeper depths were kept above -40 kPa until late in the season on a soil that should support a deep root system. The initial irrigations were initiated when the average SWP of all three depths was -75 kPa for site 2, which had the highest yield sample (Table 1). Rainfall was higher than normal for July so the later initiation appeared to be warranted.

Results from the Decagon EC-5 and the Watermark sensors in 2012 were similar to the results mentioned above for 2011. The later initiations, where there was more water removal at initiation at the 24-inch depth, had the highest yield samples collected (Table 2). Some timely rainfall occurred during the growing season, which reduced the demand for irrigation.

Watermark readings from the three different locations down the row in each set confirmed that Chris was not getting much water to infiltrate into the soil on the lower end of the field. This was due to less time water was running across this portion of the field.

Chris monitored the data regularly throughout both seasons, and felt the later initiations would save him an irrigation in most cases on these soils without reducing yields. Chris especially liked the rainfall data that was reported remotely.

Table 1. Irrigation dates and demonstration yield samples from one round bale from each site on Chris Bush, Bush farms, Greenwood, Mississippi, 2011.

		Area	Harvest Wt.		
	Irrigation	Harvested	Seed cotton		Lint (38%)
Site	Dates	acres	lb	lb/acre	lb/acre
Site 1	7/13; 7/22; 8/5; 8/30	2.76	5670	2054	781
Site 2	7/23; 8/6; 9/1	2.58	5380	2085	792
Site 3	8/2; 8/10; 9/2	2.30	5430	2361	897

Table 2. Irrigation dates and demonstration yield samples from 2 round bales from each site on Chris Bush, Bush farms, Money, Mississippi, 2012.

		Area	Harvest Wt.		
	Irrigation	Harvested	Seed Cotton		Lint (38%)
Site	Dates	acres	lb	lb/acre	lb/acre
NW	6/25; 7/11; 8/2	3.1	11480	3703	1407
SW	6/30; 7/26; 8/5	3.2	11800	3688	1401
SE	7/5; 8/7	2.9	11300	3897	1481
NE	7/10; 8/8	2.8	11190	3996	1519

Caution: Since the yields shown in Table 1 and 2 are just one sample from each site, there is no replication so determinations cannot be made of any statistical difference in yield among these sites.