ON-FARM DEMONSTRATION OF SENSOR-BASED IRRIGATION SCHEDULING IN SOUTH CAROLINA

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Abstract

The irrigation research and extension team at the Edisto Research and Education Center in South Carolina has developed an affordable soil moisture monitoring system for growers. The system uses low-cost open-source electronics, cell phone communication, and Internet of things (IoT) technologies to collect and send data from soil moisture sensors installed on farmer's fields to the Internet in real-time. The farmer can see a graphical display of the information using a computer or cell phone and can use this site-specific real-time information to make timely and accurate irrigation scheduling decisions. There is a need to promote the adoption of this technology among farmers in the state. Therefore, a new 3-year project funded by the new NRCS-CIG On-Farm-Trial program was initiated in 2020. The objectives of this project are to (1) Demonstrate the use of new sensor-based irrigation technology on commercial farms in South Carolina, (2) Evaluate the environmental and economic benefits of sensor-based irrigation technology, and (3) Train farmers and other water stakeholders in the state on the use and benefits of sensor-based irrigation technology. In 2020, on-farm trials were installed on six prototype fields, including cotton, peanuts, and soybean fields in local commercial farms. In each farm, two adjacent irrigated fields were selected. The farmers were trained to irrigate one of the fields based on the data from the soil moisture monitoring system, following simple guidelines, and to irrigate the other field following their usual irrigation practice. Suction lysimeters were also installed at three soil depths in both fields to collect leachate and quantify the environmental impact of the two irrigation management practices. Relevant agronomic and economic information was collected to compare the economic impact of the two irrigation management options.

Introduction

Competition for limited water resources is one of the most critical issues we face today. The ability to make more water available for domestic, agricultural, industrial, and environmental uses will depend on better water resources management. Over the years, research has shown that considerable savings in water and energy can be achieved if sensors are used for irrigation scheduling instead of relying on "the condition of the crop" to make irrigation decisions. For example, Khalilian et al. (2008) compared several irrigation scheduling methods at Clemson University, either using soil moisture sensors, pan evaporation, or weather data to decide when to irrigate and how much water to apply. Their results showed that irrigation based on soil moisture sensors significantly increased crop yields and increased profits by about $35/acre compared to the other methods. Similarly, Miller et al. (2012), in a two-year study at Clemson University with seedless watermelon, found that irrigation scheduling using soil moisture sensors used 50% less water compared with the typical on-farm irrigation scheduling practice. The average annual water saving was about 190,000 gallons per acre while increasing crop yield. They also found that the use of sensors reduced labor, simplified management, and showed significant environmental benefits by reducing the movement of water and fertilizer solutes below the root zone. Despite the documented advantages of using soil moisture sensors to schedule irrigation, implementation of this innovative technology at the grower level has been limited for many reasons: a) Irrigation is relatively new in this area; therefore, many farmers are not familiar with proper irrigation scheduling techniques; b) Farmers in the region are not aware of the potential economic and environmental benefits of using soil moisture sensors to schedule irrigation; c) There is a lack of trained personnel to help farmers implement irrigation scheduling based on sensors; and d) A reliable, affordable, and easy to use sensor-based water management system was not available to growers in this area. Therefore, there was a critical need for a water management system that could enhance the producer's ability to monitor irrigation needs effectively, manage irrigation practices efficiently, and increase water savings. Furthermore, there was a need for a soil moisture monitoring system that was affordable and reported data from sensors to cloud-based systems and devices, allowing producers to assess irrigation needs remotely using a handheld device. There is a need to promote the adoption of this technology among farmers in the state. The objectives of this project were to (1) Demonstrate the use of new sensor-based irrigation technology on commercial farms in South Carolina, (2) Evaluate the environmental and economic benefits of sensor-based irrigation technology, and (3) Train farmers and other water stakeholders in the state on the use and benefits of sensor-based irrigation technology.

Materials and Methods

A three-year project funded by the new NRCS-CIG On-Farm-Trial program was initiated in 2020 to address the above objectives. The project, among other things, was aimed at demonstrating the use of a new soil moisture monitoring system developed at Clemson University among commercial farmers. The system uses low-cost open-source electronics, cell phone communication, and Internet of things (IoT) technologies (International Telecommunication Union, 2013). The system allows data from soil moisture sensors installed on farmer's fields to be sent to the Internet in real-time (Payero et al., 2017a, Payero et al., 2017b, Payero, 2020). The farmer can see a graphical display of the data using a computer or free cell phone app. The farmer can use this site-specific real-time information to make more timely and accurate decisions on when and how much irrigation is needed.

In 2020, on-farm trials were installed on six commercial farmer's fields selected as prototype fields to demonstrate the soil moisture monitoring technology. These prototype fields were planted to several row crops, which included cotton, peanuts, and soybeans. In each farm, two adjacent irrigated fields were selected. The farmers were trained to irrigate one of the fields based on the data from the soil moisture monitoring system and a few simple guidelines, while they could irrigate the other field following their usual irrigation practice. Watermark soil moisture sensors were installed at four soil depths (6, 12, 18, and 24 in), and data was transmitted to the Internet every hour (Fig.1). Suction lysimeters were also installed at three soil depths (6, 12, 18 in) in both fields to collect leachate and quantify the environmental impact of the two irrigation management practices. Water leachate samples were collected after each irrigation or rainfall event. Relevant agronomic and economic information was also collected to compare the two irrigation management options' economic impact.

Figure 1. (A) Watermark soil moisture sensors and (B) Soil moisture monitoring system installed in a cotton field in South Carolina in 2020.

Results and Discussion

Figure 2 (A) shows a map of two adjacent sensor and companion fields in one of the commercial farms that participated in the project in 2020. Figure 2 (B) shows the hourly soil moisture data collected from one of the fields in 2020, including the period from early July to the end of September. As this example field indicates, the soil moisture monitoring system was accurate and reliable during the entire data collection period. Although soil moisture data were collected from four soil depths, the data logger was also programmed to calculate and report the weighted average of the four soil moisture values. Irrigation was managed by keeping the weighted average soil moisture above a pre-selected threshold (i.e. 40 kPa). The farmers were instructed to irrigate the sensor field only when the threshold was reached, which was a very simple rule. The farmers could see the current soil moisture data from the sensor filed on their cell phone in real-time, which facilitated making irrigation scheduling decisions.

The comparison of crop yields and irrigation results from the sensor fields and companion fields obtained in six farms in South Carolina in 2020 are shown in Table 1. Although the unreplicated results of the six farms represent a very small sample size to draw any definite conclusions, in general, farmers tended to apply more irrigation in the sensor field compared to the companion field. However, the additional irrigation tended to increase crop yields ranging from 7.8 to 150%. Although water samples were collected to evaluate the environmental impact of sensor-based irrigation scheduling, the lab results are not yet available and are not reported here. The project will be conducted in 2021 and 2022, which will include a total of at least 18 site-years.

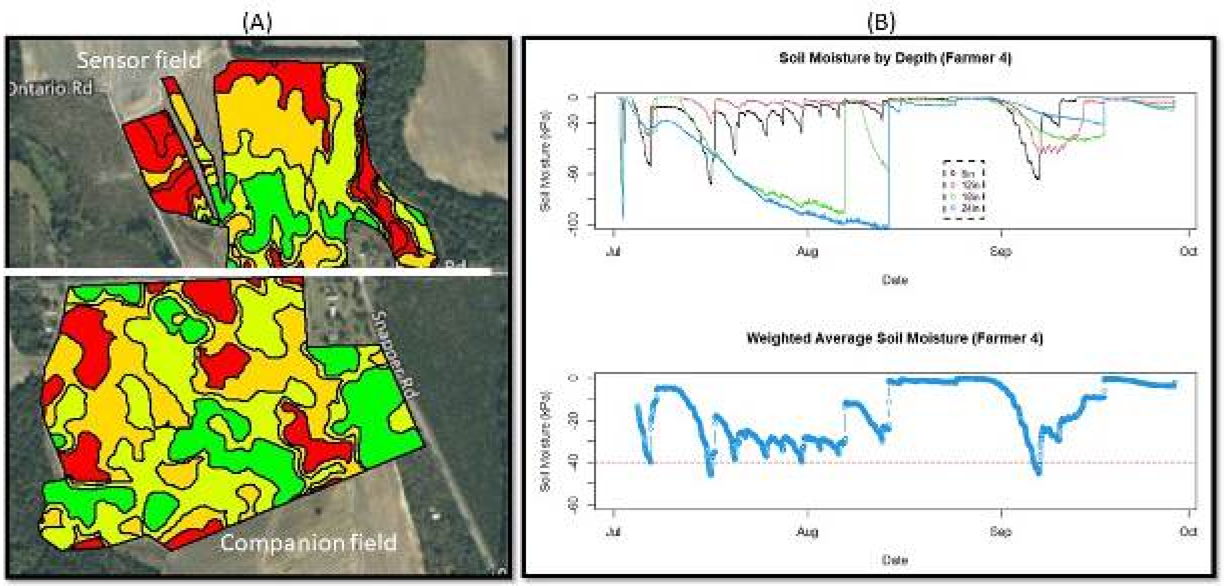

Figure 2. (A) One of the adjacent sensor field and companion field used for comparison, and (B) hourly soil moisture data collected from one of the fields in South Carolina in 2020.

Table 1. Yield and irrigation results from sensor fields and companion fields obtained in six farms in South Carolina in 2020.

		Total Irrigation (in)		Yield (lbs./acre)		
Farm	Crop	Sensor Field	Companion field	Sensor Field	Companion field	Yield Increase (%)
1	Cotton	2.5	2.5	1,292	1,110	16.4
2	Peanuts	1.0	0	5,074	4,176	21.5
3	Soybeans	4.1	3.7	6,000	2,400	150.0
4	Peanuts	4.95	3.0	6,002	5,062	18.6
5	Peanuts	1.85	0.75	5,902	5,476	7.80
6	Cotton	0.75	0.75	1,600	1,600	0.00

Summary

This paper reports some results of the first year of a three-year project initiated in 2020 in South Carolina with the overall goal of promoting the adoption of sensor-based irrigation technology among commercial growers in the state. The research team is using a new low-cost soil moisture monitoring system developed at Clemson University. The soil moisture monitoring system was installed in six commercial fields in South Carolina in 2020, and irrigation was applied based on the collected data following a simple rule. The total irrigation applied during the growing season and the resulting crop yields were compared to those obtained in an adjacent field. The adjacent field was irrigated without using sensors, following the farmer's usual irrigation practice. It was found that farmers tended to apply more irrigation when using sensors, but crop yields also tended to increase.

Acknowledgments

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