Incorporating Volumetric Water Content (Capacitance) Sensors into the Irrigator Pro-Based Irrigation Scheduling Tool

Principal Investigator: Dr. George Vellidis[1] (229.402.1278, yiorgos@uga.edu)

Project Participants: Dr. Chris Butts[2], Mr. Ioannis Gallios[1], Dr. Ron Sorensen[2]
[1]University of Georgia, [2]USDA-ARS National Peanut Research Laboratory

Project Summary:

Irrigator Pro is a public domain irrigation scheduling decision support tool (DST) developed by the United States Department of Agriculture's National Peanut Research Laboratory (NPRL) which is widely used by peanut farmers and consultants in the southeastern U.S. The original version of the DST utilizes min/max soil temperature and precipitation to provide yes/no irrigation decisions for peanuts. More recently scientists at NPRL developed a sensor-based soil water balance model version of Irrigator Pro that automates the data collection process. This version allows either manual data entry or automated entry of soil water tension (SWT) data from sensors located at 0.1, 0.2, and 0.4 m. Although Irrigator Pro (SWT) performs well, there are few commercial vendors of automated SWT sensor systems with sensors at multiple depths. This limits the flexibility and adoption of Irrigator Pro (SWT) as most commercially available soil moisture sensing systems use capacitance-type sensors and measure soil moisture in terms of volumetric water content (VWC). To make Irrigator Pro more accessible to growers and consultants, the work described here focused on incorporating VWC sensors as an automated data entry solution for Irrigator Pro. The deliverable of this project was to release a new version of Irrigator Pro that uses VWC data directly from capacitance probes.

During the 2021 growing season, data were collected from two field sites in southwestern Georgia, using replicated plot studies to develop the VWC version of Irrigator Pro. The field work was conducted at UGA's C.M. Stripling Irrigation Research Park (SIRP) located near Camilla, GA and the Hooks-Hanner Environmental Resource Center (HHERC) near Sasser, GA (Figure 1). The VWC version was evaluated during the 2022 and 2023 growing seasons by comparing its performance to that of the other two versions of the Irrigator Pro and to other advanced irrigation scheduling tools at the same two sites. The results reported on Tables 1 and 2 on the following page indicate that Irrigator Pro (VWC) performed at least as well as the Irrigator Pro (Temp) and Irrigator Pro (SWT) terms of irrigation water use and peanut yields. The VWC version of Irrigator Pro was integrated into the Irrigator Platform and made available for public use (https://irrigatorpro.org/). A journal article has been submitted to the Journal of ASABE. Ongoing evaluation of the model will continue in subsequent growing seasons with on-farm trials.

The yield results from 2021 and 2022 at SIRP where the rainfed treatment yielded as well as the irrigated treatments (Table 1) show that even our best available irrigation scheduling tools need improvement during growing seasons when precipitation meets or exceeds crop needs. More research is needed to understand the dynamics between soil moisture availability and peanut physiology and what levels of water stress are critical at different phenological stages. Irrigator Pro (VWC) and the other irrigation scheduling tools significantly out-yield rainfed treatments when growing season precipitation did not meet needs or when there were significant periods without precipitation even if growing season precipitation exceeded crop needs.

Table 1. Yield, irrigation applied, and IWUE for the 2021, 2022 and 2023 growing seasons at SIRP. Irrigation applied to each treatment includes amount applied at seeding to promote germination and activate herbicides. Tukey's HSD test was used for comparison of means by treatment (α = 0.05).

Treatment	Yield (kg ha^{-1}) by Year			Irrigation (mm) by Year			IWUE (kg ha^{-1} mm^{-1}) by Year		
	2021 [1]	2022	2023	2021	2022	2023	2021	2022	2023
IP (VWC) [2]	6517^{a}	5521^{a}	5427^{a}	55	155	89	342^{a}	38^{b}	66^{a}
IP (Temp)	6435^{a}	5154^{a}	5367^{a}	131	137	127	68^{d}	41^{ab}	47^{b}
IP (SWT)	6538^{a}	5593^{a}	4785^{ab}	112	137	89	86^{c}	44^{a}	63^{ab}
UGA SSA [3]	6583^{a}	4967^{a}	5209^{a}	74	137	108	173^{b}	40^{ab}	55^{ab}
Rainfed	6780^{a}	5267^{a}	4257^{b}	36	13	13	-	-	-

[1] Precipitation: 2021 = 681 mm, 2022 = 525 mm, and 2023 = 526 mm.
[2] In 2021, this treatment used manually triggered using VWC thresholds.
[3] UGA SSA is the University of Georgia Smart Sensor Array soil moisture sensing system.

Table 2. Yield, irrigation applied, and IWUE for the treatments used during the 2022 and 2023 growing seasons at HHERC. Tukey's HSD test was used for comparison of means by treatment (α = 0.05).

Treatment	Yield (kg ha^{-1}) by Year		Irrigation (mm) by Year		IWUE (kg ha^{-1} mm^{-1}) by Year	
	2022 [1]	2023	2022	2023	2022	2023
IP (VWC)	3997^{a}	4576^{b}	124	127	32^{a}	39^{b}
IP (SWT)	3808^{a}	5222^{a}	160	127	24^{b}	45^{a}
UGA SSA[2]	-	5114^{ab}	-	165	-	33^{c}
Rainfed	1937^{b}	3822^{c}	-	11	-	-

[1] Precipitation: 2022 = 405 mm and 2023 = 751 mm.
[2] UGA SSA is the University of Georgia Smart Sensor Array soil moisture sensing system.

Figure 1. Plot at the SIRP Newton Lateral field in which both Sentek probes with AgSense telemetry loggers (left) and UGA SSA nodes (right) were installed.