"Making Irrigator Pro an Adaptive Irrigation Decision Support System"

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Abstract

Irrigator Pro is a public domain irrigation scheduling model developed by the USDA-ARS National Peanut Research Laboratory. The latest version of the model uses either matric potential sensors to estimate the plant's available soil water or manual data input. In this project, a new algorithm is developed, which will provide growers and consultants with much more flexibility in how they can feed data to the model. The new version will also run with Volumetric Water Content sensors, giving the opportunity to the grower to see the Available Water Content in real-time. The model will run as an irrigation decision support system on a daily interval and ask the grower to apply irrigation when necessary. For the evaluation of the model, five different irrigation scheduling treatments were applied on 27 plots: Rainfed, Irrigator Pro with matric potential sensors (Vellidis et al. 2008), Irrigator Pro with irrigation triggering based on temperature readings, Irrigator Pro with VWC, and a grower standard method. The Sentek Drill and Drop VWC soil moisture probes equipped with the AgSense Aquatrac Pro telemetry were used in the field-testing, which provide readings for soil moisture and temperature at 4",8",12",16",20",24" at 30

minutes interval (Sentek 2003). The collected crop Evapotranspiration (ET_c) data then led to the development of a Growing Degree Days based crop coefficient curve. The next step will be to include an integrated ET-based soil water balance model into Irrigator Pro's available tools, which will use exclusively meteorological data and will be a model independent of soil moisture sensors. Lastly, the ET-based model will be utilized by SmartIrrigation Apps for peanut fields and will be tested and calibrated on 2022 field plot trials (Vellidis et al. 2016). This research will present data collected during the 2021 season.

Keywords

Irrigation scheduling, Decision Support Systems, Peanut Irrigation, Volumetric Water Content sensors, soil moisture, ET- based Irrigation.

Introduction

Water is the element of life. In the modern world the demand for water is increasing aggressively because of the continuously growing population, as well as the increased urbanization and industrialization. Therefore, the available amount of water for agriculture is becoming limited. As a result, the plants' water need estimation has become an important issue. The research on over-irrigation and under-irrigation losses, needs to increase if we plan to improve the water use efficiency. The team worked on the development of a tool, which provides growers with a reliable tool that functions with a variety of data entry options. Irrigator Pro is a public domain irrigation scheduling model developed by the USDA-ARS National Peanut Research Laboratory (NPRL). Previous years' data show that it is one of the best irrigation scheduling tools currently available for peanuts (Butts, Sorensen, and Lamb 2020). The research team recently released a soil moisture sensor-based version of the model that has performed very well in plot trials. The main goal is to increase the adoption of irrigation scheduling tools in Georgia and slowly expand in other states too. Increased irrigation scheduling will promote higher Irrigation Water Use Efficiency and eventually reduce the water use for agriculture purposes in Georgia. To accomplish that, the idea was to develop additional versions of the model that allow growers and crop consultants to use a wider variety of soil moisture sensor types. In addition, research will be conducted to correlate the growth stage of the plants with their root activity and development. Estimating the rhizosphere at every growth stage will provide more precise irrigation, which focuses on specific soil depths. An early version of the model was made that uses weather data to estimate crop water use instead of soil moisture sensors. This version will allow scheduling irrigation without extra equipment cost. These additional versions of the model will provide growers and consultants with much greater flexibility in how they can feed data to the model which will result in increased adoption and various use of the model. All versions will be available on a web platform as well as through a smartphone application and will be fully automated.

Hypothesis and Objectives

The main hypothesis is that the adoption of irrigation scheduling tools and the use of Irrigator Pro can be significantly increased by providing growers and crop consultants with several automated data-entry options. It is also hypothesized that increased adoption and use of Irrigator Pro will lead to higher yields and increased IWUE.

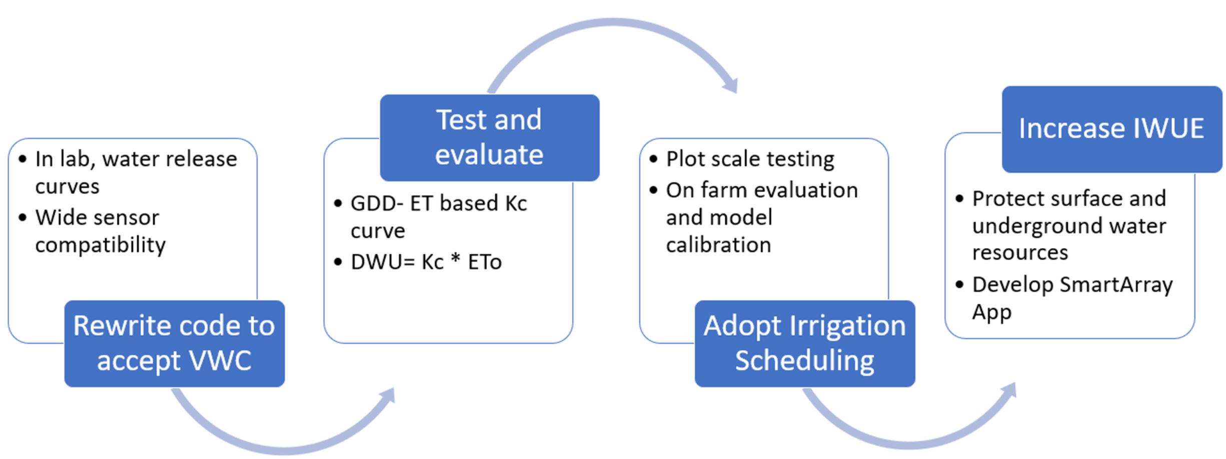
The project's goal is to make Irrigator Pro an easier-to-use irrigation scheduling tool. The following objectives will be used to test the hypotheses and meet the project's goal.

1. Modify Irrigator Pro to accept VWC data from capacitance sensors (Year 1).
2. Create soil moisture release curves that relate soil water potential (KPa) with VWC (%), to establish upper and lower irrigation thresholds.
3. Develop an ET-based version of Irrigator Pro (Year 1&2).
4. Test and compare the new versions of Irrigator Pro to existing versions and other irrigation scheduling tools on field plots (Year 2).
5. Conduct on-farm evaluations with growers and crop consultants in Georgia, Alabama, and northern Florida (Year 3).

Methods and Materials

In Figure 1, there is a brief presentation of the steps and the order of the work that has been done or will be done. This research combines lab work, data treatment and analysis, and on-field evaluation, all in a 3-year timeline (2021-2023).

Figure 1. Graphic presenting the methodology steps followed in this project.



Conclusions

The 2021 data were collected and analyzed. Figure 2 presents the yield of each treatment and the amount of irrigation applied during 2021 season. In the last column, as IWUE is defined the Irrigation Water Use Efficiency, which is equal to the yield produced divided by the amount of the water for irrigation in these plots.

According to Analyses of Variance and Tukey post hoc test among all the treatments (a=0.05), there are no significant differences amongst these treatments regarding the yield of each plot. Following that, it is safe to say that Irrigator Pro with VWC was the most efficient irrigation scheduling treatment since it produced 340kg of peanuts per hectare per millimeter of irrigation, while the second one comes at almost half of that, 173 $kg*ha^{-1}*mm^{-1}$ for the Irrigation according to checkbooks. Although 2021 was a wet year and only 20% of the annual average irrigation was needed, it provided a lot of information regarding the soil variability in the Coastal Plains and how this is related to ET variations too. In Figure 3, a GIF presents this ET variability within the growing season with a 2-week interval in one of the research areas. This figure was created using IDW interpolation using 6 different VWC sensors within the field.

Lastly, Figure 4 depicts the Kc values derived from DWU measurements (orange dots) compared to the generic FAO-56 crop coefficient (Kc) curve for peanut (blue curve). During the season, a steady underestimation in water needs was observed between the 30th and 70th day that could lead to water stress in the developing stages of the crops. Later, in the early reproductive stages, a noticeable overestimation in water demands could lead to a waste of irrigation that causes a decrease in the overall IWUE. The developed new curve is going to adjust the FAO's curve into the Coastal Plains environment and will be used to develop an automated ET-based irrigation scheduling decision support system that fits the local needs.

Appendix

	Treatments	Yield ($kg*ha^{-1}$)	Irrigation (mm)	IWUE ($kg*ha^{-1}*mm^{-1}$)
1 & 5	UGA SSA (Irrigation checkbook)	6604 [a]	73.66	173
2 &6	Irrigator Pro (VWC)	6479 [a]	54.61	340
3 &7	Irrigator Pro (Temp)	6444 [a]	130.81	68
4 & 8	Irrigator Pro (UGA SSA)	6509 [a]	111.76	85
9	Rainfed	6779 [a]	35.56	-

a = 0.05

Rain = 679.2 mm

Figure 2. Results of the irrigation scheduling study conducted at SIRP in 2021 season.

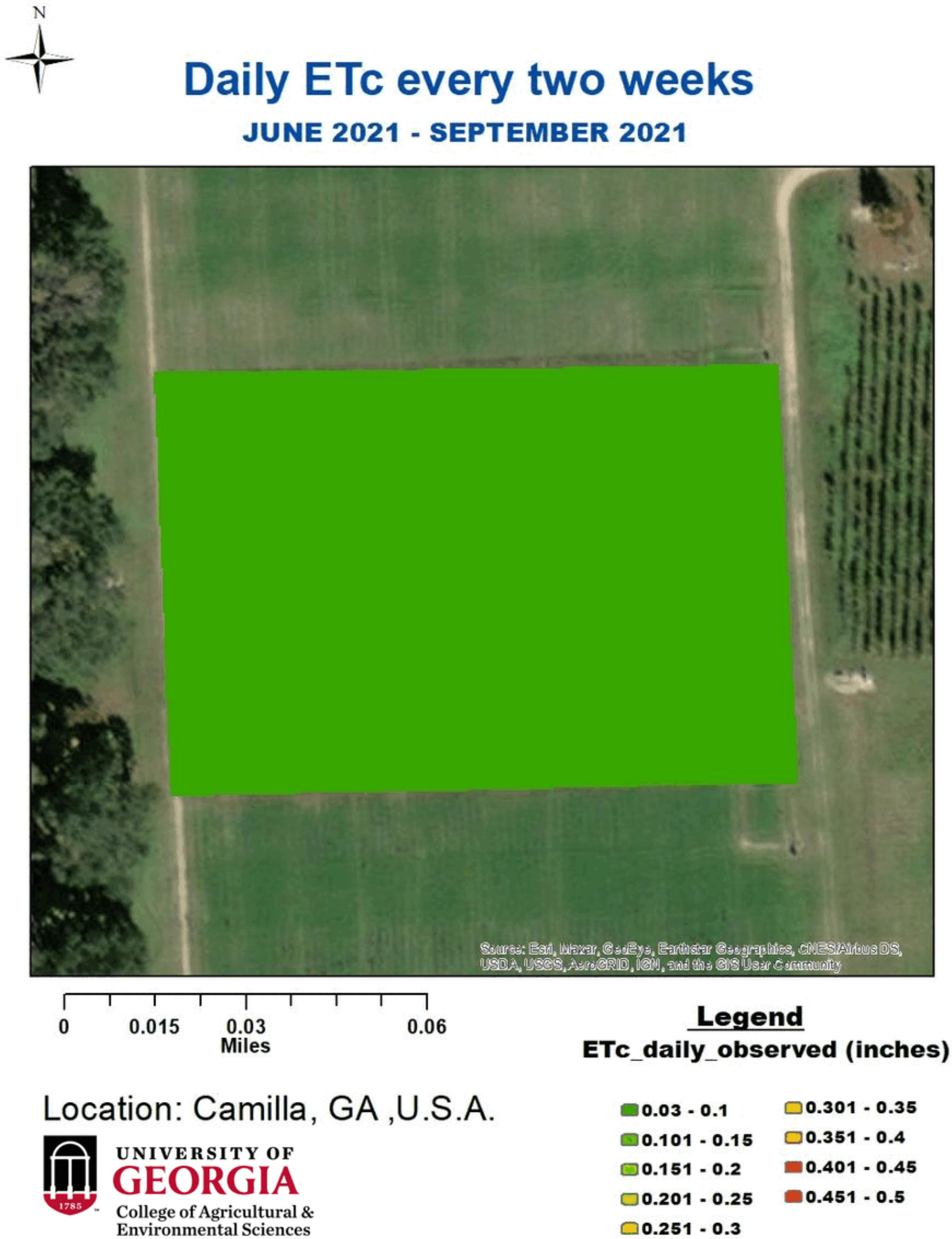


Figure 3. GIF animation depicting spatiotemporal variability of ETc in a growing season with a biweekly interval and within the same field in Camilla, GA.

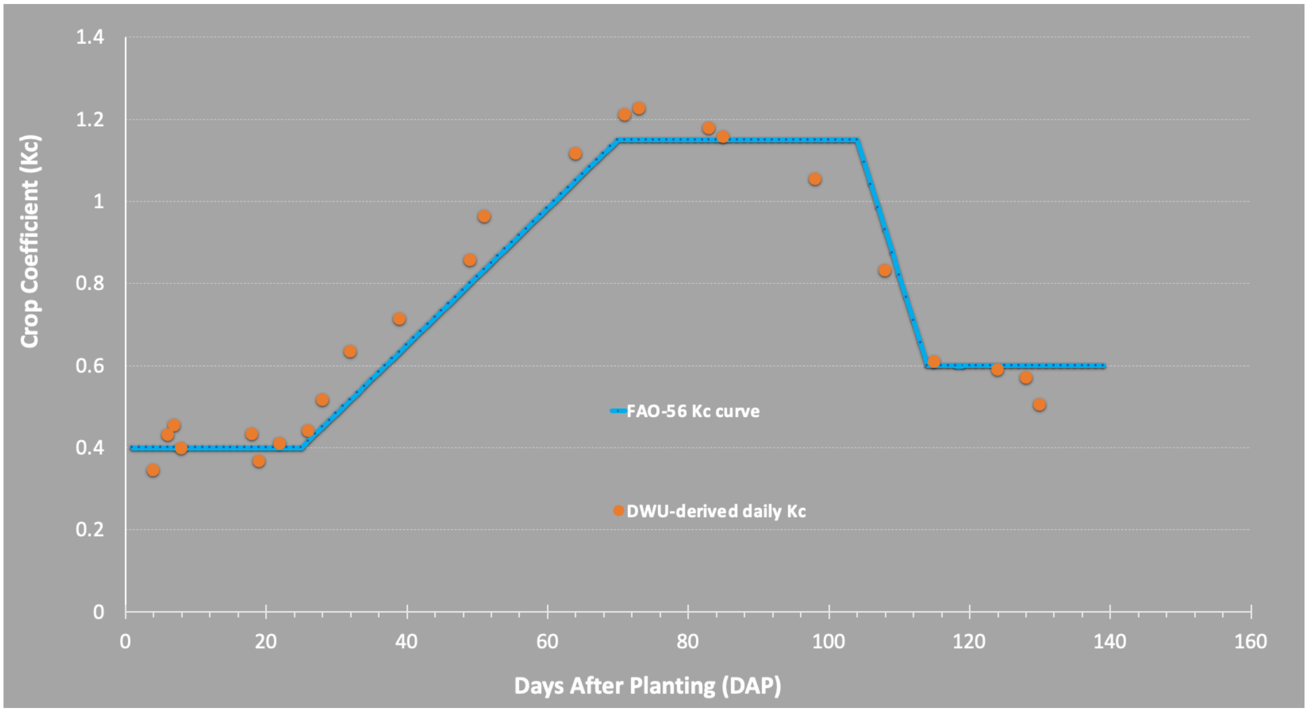


Figure 4. Kc values derived from DWU measurements compared to the generic FAO-56 crop coefficient (Kc) curve for peanut.

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