SWAMP-UGA Multi-Parameter and Multi-Depth Soil Probe

Andre Torre-Neto[1]; Ednaldo Jose Ferreira[1]; Luis Henrique Bassoi[1]; Marcos Cezar Visoli[1]; Carlos Kamienski[2]; Joao KleinSchmidt[2]; Jeferson Rodrigues Cotrim[2]; Tullio Salmon Cinotti[3]; Vasillis Liakos[4]; George Vellidis[4]
[1]Brazilian Agricultural Research Corporation, Embrapa, Sao Carlos-SP, Brazil
[2]Federal University of ABC, Santo Andre-SP, Brazil
[3]University of Bologna, DISI-ARCES, Bologna, Italy
[4]University of Georgia, Tifton-GA, USA

***Abstract*–This short paper presents a multi-parameter and multi-depth modular soil probe developed within SWAMP, a joint Brazil-EU H2020 Research Project (http://swamp-project.org/) in collaboration with the University of Georgia, USA. The probe is intended to support an innovative methodology for variable rate irrigation to be experimented in Brazil (grain crops/MATOPIBA region and wine grapes/state of São Paulo), in Italy (Reggio Emilia), in Spain (Cartagena) and in the USA (Tifton, GA). Soil moisture is the main provided parameter, but this SWAMP-UGA probe also measures the temperature and electrical conductivity. The data acquisition circuits communicate with the data transmission circuit via I2C bus to provide the modularity of multiple depths. Three standard wireless data communication options are supported: LoRAWAN, ZigBee, and BLE (Bluetooth Low Energy). There are also 3 power supply options: alkaline batteries, rechargeable LiPo batteries or lead-acid batteries. Additional predicted features are the probe installation mode and a near data transfer mode, both assisted by Smartphones and Drones. The LTE-M is also a future implementation of the probe data communication options. A study for assessing the minimum number of probes required for a statistical representation of irrigation management zones will be performed by the SWAMP team by using bootstrap, clustering and surface fitting techniques.**

I. INTRODUCTION

The proposed methodology for variable rate irrigation in SWAMP pilots is based primarily on the availability of water in the soil monitored by fixed sensors. In the MATOPIBA pilot alone there will be a grid of 10 x 10 measurement points, totalling 100 monitoring devices. The data collected by this grid approach will help with the delineation of management zones. This number should be reduced to around 30 monitoring points in a subsequent step, depending on the quantity of established zones. This is still a large number of sensors. For this reason, SWAMP decided to invest in a proprietary sensing solution instead of commercial sensors. In addition, a study for assessing the minimum number of sensors required for a statistical representation of the management zones will be performed by using bootstrap, clustering and surface fitting techniques.

II. THE PROBE

A multi-parameter and multi-depth modular soil probe was developed. Soil moisture is the main provided parameter, but, the SWAMP probe also measures the temperature and electrical conductivity. The moisture is measured by the capacitance method in percentage of volume (% V/V), the temperature by a semiconductor device in degrees Celsius (°Celsius) and the conductivity by single point method in Siemens per meter (S/m). The main issue considered in the probe electronics design was low power consumption. The measuring circuitry for these parameters are powered just long enough to perform data acquisition. For instance, the powered on longest time circuit is the one for soil moisture that takes 4 mS to be steady and 1 mS more to data be acquired.

The probe body consists of a 1500mm long and 63mm in diameter plastic tube (PR-R *polypropylene random copolymer*). The actual length depends on the number and depth of sensing modules. The probe electronics was built in multiple printed circuit boards distributed internally throughout the tube. The data transmission circuit is located at one end of the tube, which is exposed, usually 700mm above the ground. The other circuits are for data acquisition and are installed nearby the sets of metal rings that compose the sensing units, one set for each sensing depth. The data acquisition circuits communicate with the data transmission circuit via I2C bus to provide the modularity of multiple depths. The data transmission circuit allows to interchange the communication device among three options: LoRAWAN, ZigBee, and BLE (Bluetooth Low Energy) standards. There are also 3 power supply options: alkaline batteries, rechargeable LiPo batteries or lead-acid batteries. Additional predicted features are the probe installation mode and a near data transfer mode, both assisted by Smartphones and Drones.

In Fig. 1 are shown the probe assembly details and Fig. 2 presents soil moisture graphs at 15cm and 30cm depths during a 90-day period with irrigation and natural rainfall events. The generation of a daily basis irrigation prescription maps is the main purpose of a set of the probes distributed by the management zones and providing real time soil data (Fig. 3).

ISSN 2305-7254

Fig. 1. SWAMP multi-parametric and multi-depth soil probe assembly and parts

ACKNOWLEDGEMENT

This short paper has been written in the framework of SWAMP project. This project received funding from the RNP (Rede Nacional de Ensino e Pesquisa) and by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 777112. The first steps designing the probe happened at the University of Georgia, USA, during a visiting scientist program funded jointly by the Brazilian Agricultural Research Corporation and the University of Georgia, Tifton Campus.

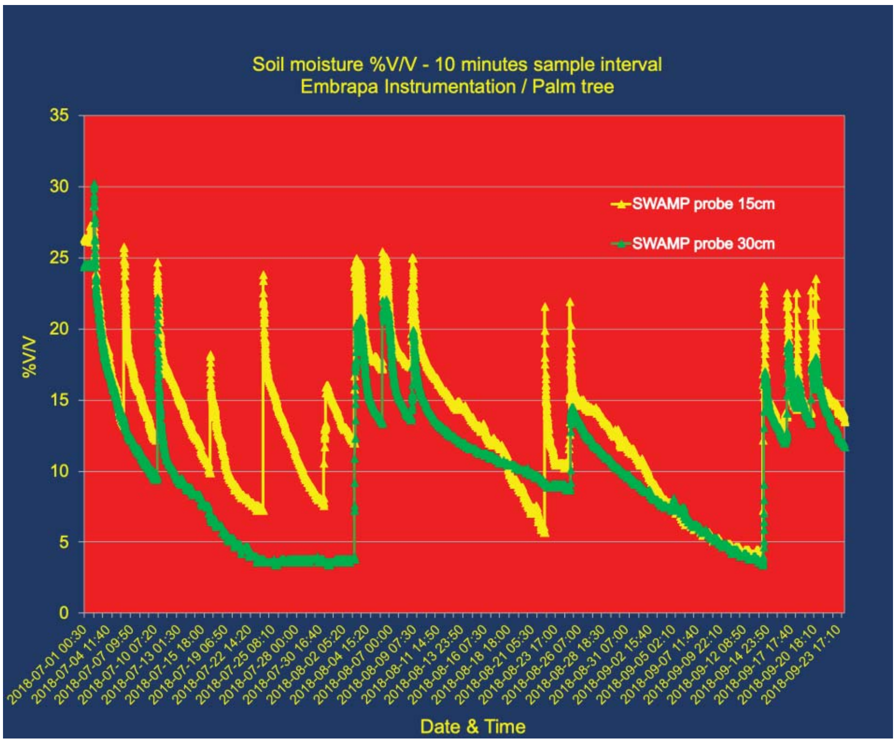
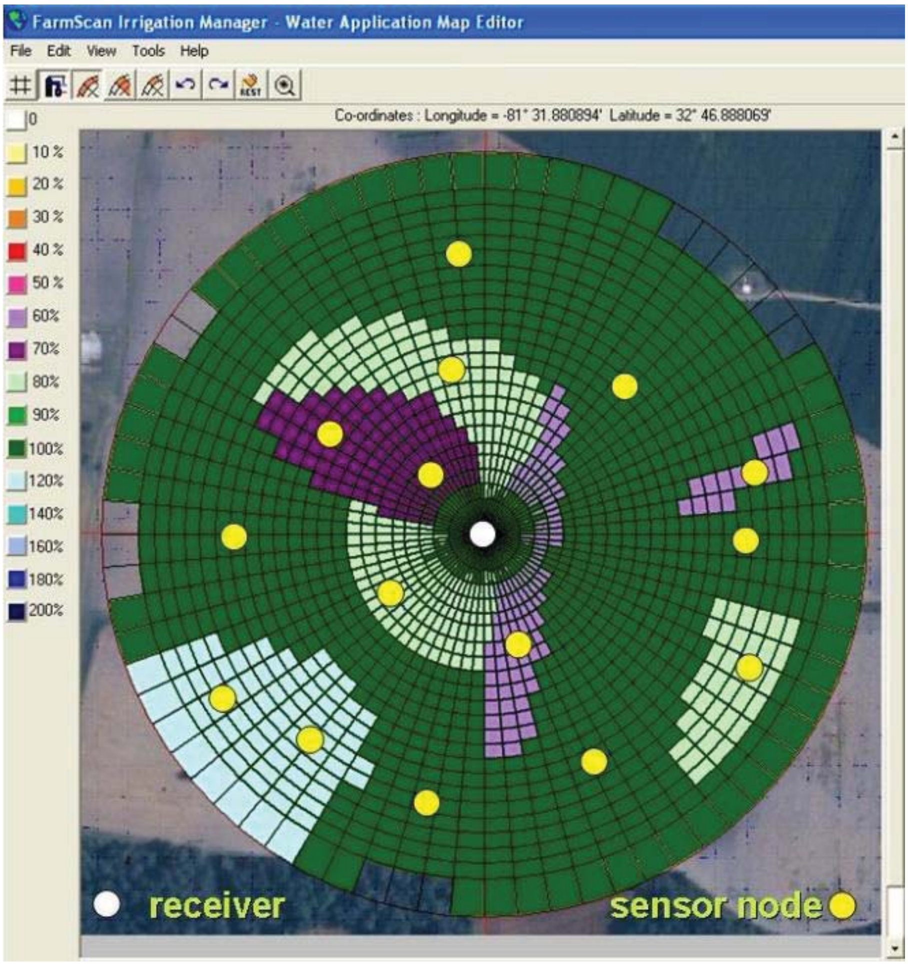


Fig. 2. 90-day period soil moisture (volumetric water content) obtained at 10 minutes sample interval by the SWAMP-UGA capacitive sensors

a) Variable Rate Irrigation capable center pivot (UGA, Tifton campus)



b) Irrigation prescription map by management zones

Fig. 3. a-b