09

FarmLink Research Report 2019

Smart Soil Sensors

Report Author

Marcus Hardie

Soil Scientist, University of Tasmania;

Cooperative Research Centre for High Performance Soils, Callaghan, NSW

Introduction

This project will develop the next generation of field-based sensors that can measure, map, interpret and communicate sensor data using new approaches that meet growers' need for information in order to make on-farm decisions.

- **The 'Smart' Shovel:** Growers have told us they are 'over' using moisture sensors, and have gone back to walking the paddock with a shovel. We will build them a better shovel, with soil moisture, salinity and compaction sensors, mapped and visualized through smart phones while in the paddock.
- **Below-Ground Sensor Data Transmission:** Growers are frustrated with the hassle of in-field sensors. We will develop the ability to send sensor data wirelessly through soil, such that sensors can be fully buried without risk of damage from stock, pests or machinery.
- **Self-learning moisture sensors:** We will develop algorithms that use existing soil moisture sensors to learn soil properties needed for use with models such as APSIM and Yield Profit, and enable growers to relate moisture content to crop stress.

Project Partners

University of Tasmania Australia; University of Southern Queensland; FarmLink; BCG; SFS; RiverinePlains; Landmark; Burdekin Productivity Services

Funding Partners

Soil CRC – Performance through collaboration

Project code - 2.2.002 Soil CRC ID - PUB2020.004

This project seeks to 'narrow the gap between the boffins and growers' to build and develop technologies and provide sensors with the functionalities that growers want to be using. Interviews and feedback from growers including the CRC workshops identified a range of constraints to the use of soil sensors (moisture) on farm.

1.0 The Smart Shovel

The smart shovel concept was developed from interviews with growers who reported that they had 'abandoned the use of sensors and probes and had gone back to walking the paddock with a shovel'. This project will build our farmers a 'smarter' shovel, designed to meet multiple needs of growers in different industries and soils. It will combine TDR moisture sensor, penetration resistance sensors, GPS and Bluetooth communications into a shovel-like device, that will enable growers to measure, map and record soil data in real time on a handheld device while in the paddock.

TIA and SenseT will develop the the integrated sensor head, which will combine sensors to measure soil moisture, salinity and compaction. USQ will develop automated mapping software and Beta human interface software. This will allow growers to be self-guided to areas requiring additional data, or direct them back to the same location for monitoring moisture changes over time at the same spot. Growers will be engaged to guide the development of the human interface software (apps) and hardware to ensure their versatility and usefulness through yearly workshops. The Smart Shovel has application in all forms of irrigated agriculture, and for informing moisture-based decision making, i.e. sowing and tillage timing in rainfed agriculture (see comments by Birchip Cropping Group) and irrigation management in more intensive systems.

2.0 Below-ground data transmission

The concept was first identified by interviews with growers who complained about above-ground sensors being easily damaged by machinery, stock and pests, and the hassle of moving sensors out of the way of in-field machinery. We will work with our grower groups to better understand the network typologies (placement depth, soil types, sensor spacings, longevity) required by different industries. Research will consist of two phases (i) **below to above-ground nodes**, in which the buried sensors send data through the soil to a nearby above ground node and then onto a gateway, and (ii) **below to below-ground nodes**, in which we will use radio signal attenuation to map changes in soil moisture between sensor nodes.

Research will seek to optimise signal transmission distance at the lowest possible power consumption. Research will explore the use of different forms of low power wide area network technology (LoRa, Sigfox, NbIOT, etc), directional antenna, variable frequency chipsets, noise-reduction protocols, variable soil moisture-transmission power requirements, soil type relationships on data transmission, and power harvesting opportunities. In collaboration with Assoc Prof Joarder Kamruzzaman (Federation University) research will explore the effects of soil properties (texture, conductivity, dielectric permittivity, and magnetic permeability) on signal transmission.

3.0 Self-learning moisture sensors

This project concept was developed in response to growers' frustrations with existing sensors and the usability of modelling tools, namely (i) the amount of data generated by soil moisture probes, and the difficulty associated with interpreting the data, and (ii) the inability to relate APSIM and Yield Prophet predictions to actual soils on growers' properties. This sub-project seeks to provide solutions to both these issues by using machine learning techniques to determine the soil water retention function for any soil in which a logging soil moisture probe is installed. By understanding the retention function, it is then possible to (i) relate soil moisture to crop moisture stress, (ii) relate soil moisture to soil water limits such as refill points and field capacity, and (iii) determine the soil parameters (drained upper and lower limits) needed for models like APSIM and Yield Profit. This part of the project will be largely conducted as part of a PhD.