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FarmLink Research Report 2019

Technology and tools connecting farmers to their soil

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Trial Site Location TAIC, Thuddungra, Lockhart

Introduction

Technological solutions have emerged to assist cropping enterprises achieve two objectives: maximising yield potential across varying seasonal conditions, and more efficient use of plant nutrition.

Broadacre agriculture uses the 'yield gap' to evaluate the difference between potential yield achievable on any parcel of land and actual yield. Moisture available to the plant is the key factor that drives yield in any season, followed by nutrient availability. Without sufficient moisture however, nutrient availability is irrelevant. Studies undertaken by CSIRO and GRDC show that on average, NSW wheat farmers currently achieve 49% of their potential yield. If 80% of yield potential is the practical ceiling for a wheat broadacre production system, 31% of wheat production is left unrealised annually in NSW. This production loss, coupled with the practice of applying nutritional inputs where yield potential cannot be met, has consequences for both the natural environment and farm profitability.

Considerable spatial variability of rainfall and soil moisture at a regional and even farm level makes matching plant nutrition to water available to the plant through soil moisture and in-season rainfall difficult. Accurate localised data can improve the level of confidence a grower feels when approaching decisions about crop choices for rotations and inputs. However to date, many farmers have not yet adopted this technology and the decision-making benefits it can provide, citing a lack of knowledge, high cost and poor connectivity as some barriers to adoption.

This project aims to solve these issues by facilitating the uptake of new, more cost-effective technology. Low-band width LoRaWAN gateways were installed at three sites and sensor data networks were installed across five farm sites (one at the Temora Agricultural Innovation Centre and four commercial farms). This enabled the connection of site-specific soil moisture and nutrient probes, automatic weather stations and rain gauges. Information provided to the growers at the outset supports them in identifying best practices and timing to ensure maximum productivity and profitability at a paddock level, given seasonal constraints. While 2019 was a difficult season due to the dry conditions, it is hoped that 2020 will provide conditions conducive to a more comprehensive exploration of the technologies' capabilities. The project aims to support longer-term adoption by demonstrating how the technology is used, and its efficacy for data capture and improving accuracy and confidence in decision-making.

Project Partners

FarmLink change • adapt • prosper

Goanna Ag

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Funding Partners

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Figure 1. Installation of soil moisture probes at TAIC.

The objective of this project is to assess the ease of introduction, value for money and applicability of currently available soil sensors and connectivity solutions.

There is a clear gap between the information farmers are using to make cropping systems decisions and what new technology is making possible to enable science-based, measured information from specific paddocks. The Bureau of Meteorology (BOM) has a network of automatic rain gauges around the state. However, given the spatial variability of rainfall and soil moisture, more accurate localised or site-specific measurement is needed to underpin a farmer's decision-making throughout the season as soil moisture and rainfall fluctuates. These data can instil confidence in the farmer that the extra cost of inputs they are contemplating to achieve higher yields will actually deliver this result.

Despite improved technologies coming on line and costs coming down, many farmers haven't yet adopted this technology. Farmers have relied on manual reading of gauges, sensor technology has been too expensive and/or connectivity has been poor or unavailable, or too expensive to support adoption.

This project aims to solve these issues by facilitating the uptake of new, more cost-effective technology. A low-cost, low-band width LoRaWAN data network was installed across five participating farm sites (one at the Temora Agricultural Innovation Centre and four commercial farms), enabling the connection of site-specific soil moisture probes, rain gauges and temperature sensors.

This project aims to demonstrate the effectiveness of new generation sensors and viable solutions for connectivity constraints. The novel LoRaWAN technology is able to overcome the connectivity issues often experienced in rural areas, by using low-powered senders to transmit small data packages long distances. It targets two barriers to adoption of sensor-technology-supported decision-making in broadacre cropping: 1) knowledge and understanding of the sensors and their commercial-scale applications; and 2) an inability to transmit and therefore use in real time data collected via a sensor network.

Data from the installed sensors is centralised on a single platform. Each participating grower has access to their information behind a secure login. Information provided to the grower supported them in identifying best practices and timing to ensure maximum productivity and profitability at a paddock level, given seasonal constraints.

There were 25 moisture probes installed for the project (0-80 cm with sensors every 10 cm), eight temperature sensors and 10 rain gauges. Moisture probes were installed across a variety of soil types and under a number of different crops types to assess their respective impacts on PAW. Soil characteristics at each moisture probe site were assessed by a round of deep soil coring at the start of the season. Temperature sensors were selected by some growers to examine the impact of landscape on frost throughout the season while rain gauges were used by growers to remotely log rainfall across their operations.

In accordance with the intended purposes and outcomes of this program, the project aims to increase the capacity of farmers to adopt the latest sensor technology for better management of their inputs and water resources by:

- Providing a practical, hands-on demonstration within travelling distance of their farm.
- Applying the technology to the conditions and circumstances of local farming systems and seasonal conditions.
- Establishing the economic returns (if any) of upgrading to this technology, in improved yields and more efficient use of resources (water & plant nutrition).

The adoption of this technology for production reasons will also have complementary benefits to the broader community and sustainable resource management across the landscape. Better decision-making about available resources and inputs, and adaptability to varying climatic conditions between and within seasons, has the potential to improve the economic viability of dryland cropping production systems across the region. The ability of each individual business to manage the risk of climate variability helps to insulate the broader community from the economic effects of changes to weather patterns currently being experienced in south-eastern Australia. The more efficient use of available resources in a production setting also assists with the implementation of long-term, sustainable natural resource management practices across the landscape.

Because this sensor technology, integrated with a decision-making tool and low-cost connectivity option, has only recently become available, it is important to validate commercial claims about its benefits and provide farmers with the hands-on experience and knowledge necessary to make informed decisions about its application.

2019 proved to be a difficult season to conduct the project due to the dry conditions. Soil moisture was negligible on all trial sites, negating the need to make decisions about late-season operations and inputs. It is hoped that 2020 will provide conditions conducive to a more comprehensive exploration of the technologies' capabilities. The project's aim is to support longer-term adoption by demonstrating how the technology is used, as well as its efficacy for data capture and improving accuracy and confidence in decision-making.

Grower Feedback

Eight growers took part in the trial across four farm sites, plus the Temora Agricultural Innovation Centre (TAIC) site. Participants represented a cross section of enthusiastic early adopters and those who were a little more sceptical and who were getting involved to see where it might take them.

The growers took part in workshops that were designed to ascertain their experience with the technologies and devices. Chris Minehan from RMS presented to the group and gave background information on soil properties and why they might differ. He covered the fundamentals of plant available water (PAW), soil characteristics and landscape effects.

The workshop also involved examining the process of site selection and how that might influence a grower's decision on how many probes to purchase and where to locate them. The initial installation of the LoRaWAN gateway still represents a substantial upfront cost for growers, but subsequent sensors are relatively cheap. Therefore LoRaWAN offers a cost-effective solution for those growers who may want to install a lot of sensors, i.e. more than five.

Installing a large number of sensors with previous systems would have been cost-prohibitive. However because the LoRaWAN system makes it more feasible to install a network of sensors, growers are able to use the data they generate to answer questions around things such as rainfall distribution and moisture variability among different soil types.

Following the workshops, the growers were surveyed about their level of knowledge in the areas of site selection for moisture probes and plant available water capacity (PAWC). All participating growers recorded an improved understanding across these areas. They were asked to identify barriers to their uptake of sensor technology (e.g. cost, lack of knowledge, poor connectivity, etc.), with cost being cited as the most common barrier to uptake.

Broden Holland

Broden Holland farms with his father Chris (who also participated in the trial) at Thuddungra, north west of Young. They run a 4500ha mixed farm cropping wheat and canola, and running self-replacing ewes with a three-year lucerne phase. Average annual rainfall is around 600 mm per year.

"We heard about the project and had previously done a lot of work with Eva (Moffitt) so we were keen to get involved. We already had one moisture probe in, which we installed in 2016, and that has been helpful for us.

There was a workshop at the start of the project with some background information and then growers then collaborated about what we hoped to get out of the trial. We worked closely with Eva on site selection as we sometimes differed on where we thought the probes should go. Ultimately we worked with soil maps and yields, and settled on a low and high pH area, a low and high yielding area, as well as a historically high and low protein area based on crop rotation.

We installed eight soil moisture probes in total – five with the project and another three we bought ourselves – so we had some good comparisons between high and low pH areas – and another block in which we were comparing two paddocks: one just out of pasture, and one five years into a cropping rotation.

The probes allow us to make decisions about rotations and late-season inputs. The probe tells you what the moisture level is every 20-30 cm. Last year, in 2019 we didn't spread any urea on our wheat, because we knew we had no subsoil moisture. Had we had some subsoil moisture, and then received a little 10 mm shower, we may have done so. It's not the thing you base your whole decision on, but it's another bit of clarity that builds your confidence.

If we have 150 mm of sub-soil moisture (around half full), we know we'll get a half decent crop, but if we are at 100 mm we're in trouble. We had only 60 mm of moisture at the start of 2019, so we pulled out of canola and into wheat. We got to harvest and it ran out of juice, as we knew it would. We barely looked at the probe this year simply because of the year it was.

We now have three rain gauges across the LoRaWAN network, so we can see that one end of the farm might get 10 mm while the other end gets 40 mm. It would be good to have a few more soil moisture probes around to build on this information. Having said that, the probes really need to be 2-3 m, rather than the 80 cm we got, to be really useful.

Cost is a barrier to these technologies, because everything has to be justified. This year wasn't good but for us it's a long-term thing. With long-term data I can see their value."

Figure 2. Soil characteristics at each moisture probe site were assessed by a round of deep soil coring at the start of the season.

John Stevenson

John Stevenson runs a 100% dryland cropping operation on 8500ha at Lockhart. The soils are predominantly red brown earths to grey vertosols and annual rainfall across the properties is between 430 mm to 480 mm per year.

"I was one of the people who instigated this project because we already had the LoRaWAN network with rain gauges. The reason we put it in was because of the spread of our properties; to check our rain gauges was a 240km round trip.

We were interested in the technology from both a labour saving and data accuracy point of view. When you are manually checking rain gauges, you don't know how much rain you've had until you go and check them. And even then, you wouldn't be exactly sure when it fell or how heavy it was. Now we know distribution and intensity. Every time 0.2 mm of rain falls, it records it. So you can measure it over time and see how heavy the rainfall has been from the data it gives you.

Now we know the rainfall in better detail, we wanted to be measuring soil moisture as well, to give us an accurate assessment of our plant available water. The soil moisture probes will allow us to do that. The attraction of the LoRaWAN network is that it is so much cheaper than anything over the 3G network. It's also a lot less power intensive. A D-sized battery will last a year, so you don't have to worry about solar panels. You can see the battery status remotely, so if it needs new batteries you can just replace it and keep going.

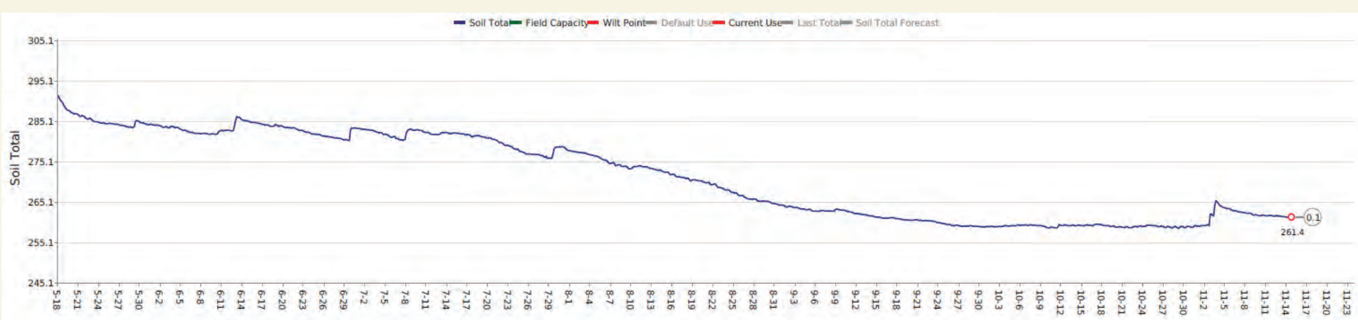

Figure 3. The Goanna Ag user interface charts soil moisture levels.

The soil moisture probes certainly showed us when we ran out of water. What I would like to see is them going to a greater depth because at the moment they are only going to 80 cm and our roots are going much deeper than that. So we need to get the system developed where it is much better suited to a dryland situation. The ones they used came straight out of irrigated systems where there is obviously a water supply that is easier to monitor and easy to fix.

It's been pretty easy to implement, although we've had a few hiccups. We've had a couple of the sensors fail and that's just a case of diagnosing and replacing. A lot of this technology is still at prototype stage but the guys from Goanna have been pretty helpful. The app is very easy to use. You can look at it on your phone or PC and download the data if you need it.

They need to work a bit harder on technology that we can leave in place. I don't think they have put enough thought into that. We need to be able to leave it there for years and just crop straight over it without worrying about damaging it. Some of it is above the soil surface. It's the electronics above the ground that are going to be giving us issues.

The data may influence rotation decisions for some growers but for us it's more about making good decisions on nitrogen through the season or maybe late-season fungicide applications. If you don't have sufficient soil moisture it's probably not going to warrant high-cost inputs.

Next steps? I want to see the network extended and a higher density of sensors so we can really start getting some rainfall maps and some soil moisture maps. We can also start to then determine the direction of rainfall. If you have a high enough density of sensors, you'd actually be able to model where that came from and where it went. At the moment, they are trying to make soil moisture maps based on rainfall but they're assuming it's a circle of rain, which is not quite right. I think down the track they'll be able to integrate them with radar, so you'll actually be able to overlay radar images of where rainfall occurred.

As the data pool grows, you'll actually be able to use your soil moisture probes to tell you infiltration rates of different soils and how your crops are extracting it."

Mark Day

Mark and Steven Day manage a dryland winter cropping operation at Lockhart. The soils are predominantly red clay loams and sodic clays and the annual is 450 mm per year.

"We already had a soil moisture probe on our farm – a different model – when we got involved in this project but it wasn't going be cost-effective to roll that particular model out across the property. I was interested in seeing how cost effective the LoRaWAN network was going to be. I also see the benefits of this technology in the remote monitoring capabilities – that's going to be a big plus. Being able to monitor weather on your phone.

I think these technologies – combined with gut feel – can help us with decision making on crop rotations and late-season inputs. Whatever crop we have got in, it can help us decide how hard we go with nutrition.

There were a couple of hardware issues and they put in some out-dated technology – we can't sow and spray over them without laying them down. That is a pain, because it means it's only good then for that year of sowing. The existing one we owned, which we've had for six years, is subterranean.

The best part of it was the wireless rain gauges. After the summer storms we were able to see the differences around the farm, which makes things more streamlined for summer spraying.

Down the track I'd like to see remote and networked grain moisture and temperature monitoring. That would be really useful for the grain we have stored on farm."

Fig 4. A rain gauge in a canola crop