Improving our understanding of soil moisture and how to utilise it

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Key messages

- Out of season rainfall and stored soil moisture were found to be key factors in driving grain yields across most farming systems on the Eyre Peninsula in 2021.
- Collating and interpreting information from a range of sources including plant available water, previous grain yields and soil testing across the landscape can maximise returns and reduce risk.
- Improving knowledge of soil characteristics can add considerable value to monitoring soil moisture probes.

Why do the trial

It's well understood that rainfall limits grain and pasture production across Eyre Peninsula. Farmers also understand the value of measuring rainfall but measuring how much of that rain is present as soil moisture at any one time and where it is in the profile using tools such as soil moisture probes (SMP) is a relatively new innovation.

On face value, if a shortage of water is the biggest limiting factor to the farming business, then knowing the quantity of soil water present and understanding crop water use patterns should be useful. However, this knowledge only becomes powerful when profitable decisions can be made using the information.

To increase understanding of soil water across Eyre Peninsula and investigate opportunities to utilise it more effectively in a variable and changing climate, AIR EP, together with its research and extension partners have developed a project aimed at improving the resilience of EP farmers into the future.

How was it done?

Step 1: Creating a viewing platform

SMPs are a relatively cheap and reliable tool to measure soil moisture. Being able to quickly view and assimilate information that SMPs provide not only encourages regular use but also increases knowledge of the effects that different rainfall events, and crop/ pasture growth have on SMP outputs, with the flow on of confidence in using this tool to make management decisions.

Through the Resilient EP project, AIR EP engaged software development company Square V to develop a new platform to display SMP data of the 42 probes on the EP network in an intuitive manner that would allow users to quickly gather required information with a few clicks optimised for use on a mobile phone.

Links to all 42 SMPs that are part of the AIR EP network can be found at: https://probes.airep.com.au/

Step 2: Soil characterisation

SMPs provide information on relative changes in soil moisture, through measuring changes in capacitance at a range of points (usually 10 cm intervals) down the soil profile. However, these outputs do not readily equate to mm of plant available water and have been found to be affected by higher temperatures over summer and soils with higher levels of salt/electrical conductivity.

To help understand the relationship that SMPs readings have with plant available water and to improve accuracy of the outputs AIR EP have engaged SARDI to characterise soils for plant available water capacity and CSIRO to work through correction factors to improve SMP accuracy.

Algorithms are currently being applied to soil moisture probe outputs to improve their accuracy in high temperature/electrical conductivity situations. These are being incorporated into probe outputs found using the above link to the AIR EP website.

At the conclusion of the 2021 growing season 31 of the soils adjacent to SMP sites have been characterised for plant available water, a process that involves calculating how much water a soil can hold (drained upper limit), how much moisture a crop can remove from the profile (crop lower limit), including the effect of toxic elements such as boron, and calculating soil bulk density that allows conversion from gravimetric measurements to mm of soil moisture (volumetric).

This knowledge derives plant available water capacity or 'bucket size' - how many mm of plant available water that soil can hold. Bucket sizes are largely driven by soil texture and how deep in the profile toxic elements such as boron and salinity occur. On Eyre Peninsula plant available water content of some soils has been found to be as low as 20 mm and as large as 150 mm. The capacity of a soil to store water can greatly vary across a paddock, however SMPs as part of the AIR EP network have tended to be on soils well between these extreme values.

The quantity of plant available water becomes important at times when crop/ pasture growth is using more moisture than is being replaced by rainfall. This is often most noticeable when crops and pastures are large, temperatures are higher, and rainfall is more sporadic such as in spring.

Step 3. Using soil water to create a yield target.

Once a soil's water holding characteristics are understood, the information can be used in combination with climatic conditions to help create a potential yield.

Plant growth models such as Agricultural Production Systems sIMulator® (APSIM®) are able simulate a crop's growth in a given climate and soil type to provide a range of scenarios on how crop/ pastures will perform, with soil moisture being a critical parameter in calculations.

Yield Prophet® utilises APSIM® outputs to deliver information on crop growth, yield potential, and potential nitrogen requirements based on historical climatic conditions for a location in way designed to be easily understood by growers and advisors. Having accurate soil characterisation is critical to accuracy of Yield Prophet. Using the characterisations completed as part of this project in 2021 saw a high correlation between Yield Prophet® predictions and actual yields. This means tools such as Yield Prophet® can be utilised with some confidence to help plan target yields.

Step 4. Evaluating management strategies, based on increased understanding of soil moisture.

Once water limited target yields are established, then a range of hypotheses can be explored to improve profitability and/or reduce risk. To test and work through management options based on these hypotheses across the broad range of soil types and environments found on Eyre Peninsula, EPAG Research worked across eight focus paddocks in 2021 (figure 1).

What happened

Figure 1. Map displaying the position of 8 focus paddocks across the Eyre Peninsula; Wangary, Cockaleechie, Yeelanna, Lock, Wharminda, Cootra, Pinkawillinie, Minnipa.

The eight paddocks were monitored with:

- Segregation of zones by historical yield potential within the paddock.
- Pre-season deep N testing across yield zones.
- Understanding of plant available water capacity at the soil moisture probe.

- Group discussions with local grower groups on yield potential and its use in combination with soil moisture, nutrition, and seasonal forecast information.
- Yield and protein data post-harvest.

Small discussion groups were held in paddock to bring together growers, consultants and researchers. The approach was to understand the information available, and how growers used it to decipher yield potential. Information such as starting N, historical yields, and soil type to depth were all supplied to those involved. Once yield potential was considered and a target was decided on, how individual farmers intended on proceeding from this point regarding inputs was discussed.

Some factors that influenced decision making when it came to inputs were the inclusion of livestock into their system or not, grower optimism, growers' belief in N remaining for following seasons, soil type (risk of leaching), climate risk (frost, heat) and cost of inputs/outputs.

Lessons learnt from five of the focus paddocks are reported below. All 8 paddocks were not included as they either taught a similar lesson to another or did not add to the depth of this discussion.

Table 1: Focus paddock history, rooting depth, April 2021 plant available water (PAW), April 2021 mineral nitrogen (N) and grain yield in 2021.

Paddock	Crop 2020	Crop 2021	Rooting depth (mm)	April PAW (mm)	April N (kg/ha)	April - Oct Rainfall (mm)	Yield (t/ha)
Cockaleechie	CL Canola	Wheat	1200	27	105	327	6.57
Lock	Vetch	CL Canola	800	91	110	228	1.50*
Cootra	Wheat	Wheat	1100	11	60	219	3.44
Minnipa	Wheat	TT Canola	1100	10	195	212	1.10*
Pinkawillinie	Wheat	CL Barley	600	60	45	162	2.93

NB all grain yields were adjacent to SMP except canola crops marked with *which were whole paddock yields.

What was learnt from 2021

Cockaleechie

How historical soil moisture can be used to increase confidence with in-season decision making.

Once a soil moisture probe has been in place for several seasons, growers are able to use the relative outputs in combination with yields obtained to increase their confidence in targeting grain yields.

In 2019 the Cockaleechie SMP indicated stored soil profile in July was below half full (table 2). Soil moisture in 2021 was higher at around 75% full. Rainfall after July in 2019 was below average and the crop took a yield hit of an estimated 0.5 t/ha with a wind event just prior to harvest.

Table 2. Comparison between yields given higher stored moisture levels mid-season in 2021 and similar end of season rainfall. *2019 saw a significant wind event at harvest when an estimated 0.5 t/ha was lost.

	Crop prior	Crop	End July stored soil moisture	Aug- October rainfall (mm)	Yield (t/ha)
2019*	Wheat	Wheat (Scepter)	40%	91	5.5
2021	Canola	Wheat (Vixen)	75%	103	6.2

As end of July 2021 soil moisture levels were higher than at the same time in 2019, the grower had increased confidence that crop yields would exceed the yields of 5.5 t/ha achieved in 2019 when below average rain fell between August and October. This confidence was applied in the form of applying extra in-season N to target yields around 6 t/ha, which were realised at harvest.

Lock

Understanding yield potential so opportunities aren't missed

Target yields for canola in the Lock area on the soil type where the SMP is located are typically set at 1t/ha. April PAW of 91mm was the highest recorded stored soil water since the probe had been installed (in 2016). This presented an opportunity to push 'usual' yields.

Starting soil nitrogen (110 kg N/ha), N applied at seeding (10 kg/ha) and Yield Prophet® in-season N mineralisation predictions (10 kg/ha) totalled 130 kg/ha of N available to the canola crop. Using a N efficiency of 80 kg N/tonne of grain suggested the crop had sufficient nitrogen to achieve 1.63 t/ha with existing N after sowing.

In July Yield Prophet® simulated yields of 2.2 t/ha or higher in 50% of years, based on historical climatic conditions. This also means that canola yields could be lower than 2.2 t/ha in 50% of years. In this instance, after a group discussion on the range of possibilities, the grower decided not to target 2.2 t/ha but was comfortable that sufficient N was available to achieve a canola yield at least 50% higher than his target yield for most of the paddock. But to hedge bets, another 30 kg/ha N was applied to areas of the paddock where yield was historically higher.

The dry period from mid-August to end of September reduced the Yield Prophet® 50% yield simulation to 1.5 t/ha. This yield was realised at harvest.

The extra information provided through soil testing at the start of the season, the SMP output and Yield Prophet simulation gave the grower confidence to adjust yield expectations to a level where he was comfortable with the level of risk and was able to achieve higher than average grain yield without having to apply more N fertiliser across the whole paddock.

Cootra and Minnipa

Paddock variation and using it to your advantage.

Understanding paddock variation, in terms of how changes in soil type can affect yield potential can be prove highly beneficial. Variable rate technology, prescription maps and specialists that can employ its use on farm are available (at a cost), to those that want to implement its use on farm.

Two focus paddocks at Cootra and Minnipa have highly variable soil types within the paddock with yields varying from 1.5 to 3.5 t/ha in each season. To put within paddock variation into context, if there were two paddocks side by side and one yielded 2.5 t/ha better than the other should they be treated the same?

Preliminary results from using variable rates within each paddock revealed several main points.

- Maximum yields on the better zone will not be realised unless inputs in these areas are greater than those in poorer areas.
- Total paddock inputs often remain similar.
- Easy savings can be made by applying less on lower yielding areas.
- Yield data and sometimes protein data are a reliable way to establish zones within a paddock. This is best done over several seasons, with knowledge of rainfall and other influences that most growers will know, (heat events, rainfall, etc.).

Pinkawillinie

The importance of understanding stored soil moisture

At Pinkawillinie, a barley yield of 2.93 t/ha was achieved in 2021. Growing season rainfall at this site was 162 mm (with 18 mm falling in October when the crop was largely mature). 60 mm of PAW in was measured (to 1m depth) at the start of the season in April. This provided an invaluable reserve during the growing season, particularly during September when only 4 mm of rain was recorded.

In this instance, the ability to measure stored soil moisture at the beginning of a season helped give the grower confidence that despite below average rainfall profitable yields were still possible and could assist his decisions regarding fertiliser purchase and grain marketing. The information didn't change the grower's decisions in the way he managed this crop, but it gave confidence and peace of mind.

What does this mean?

At Lock in 2021 we learnt to utilise knowledge of plant available water and yield potential to realise the full economic capabilities of your crop.

Pinkawillinie taught us the importance of preserving stored soil moisture to minimise risk in a low rainfall environment on a soil type with a high plant available water capacity.

Understanding patterns in stored soil moisture and crops to help predict end yield and therefore required inputs was shown at Cockaleechie where yield potential seen in prior years meant a high target could be set for 2021.

Both Minnipa and Cootra demonstrated the importance of understanding variability within paddock and utilising this knowledge to maximise profitability through use of variable rate applications.

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Logos: AIR EP, Resilient EP, Aust Gov Landcare, EPAG

Minnipa
Av. Annual: 324mm
Av. GSR: 241mm
2021 total: 376mm
2021 GSR: 212mm
2018 Crop: Wheat
2019 Crop: Lentil
2020 Crop: Wheat
2021 Crop: Canola
Soil type: red loam

Buckleboo
Av. Annual: 288mm
Av. GSR: 195mm
2021 total: 289mm
2021 GSR: 162mm
2018 Crop: Barley
2019 Crop: Pasture
2020 Crop: Wheat
2021 Crop: Barley
Soil type: sandy clay loam

Cootra
Av. Annual: 334mm
Av. GSR: 249mm
2021 total: 249
2021 GSR: 219
2018 Crop: Barley
2019 Crop: Pasture
2020 Crop: Wheat
2021 Crop: Wheat
Soil type: sand over light clay sand

Lock
Av. Annual: 385mm
Av. GSR: 249mm
2021 total: 322mm
2021 GSR: 228mm
2018 Crop: Wheat
2019 Crop: Wheat
2020 Crop: Vetch

2021Crop: Canola
Soil type: sandy loam over sandy clay loam

Cockaleechie
Av. Annual: 421mm
Av. GSR: 340mm
2021 total: 418mm
2021 GSR: 327mm
2018 Crop: Wheat
2019 Crop: Wheat
2020 Crop: Canola
2021 Crop: Wheat
Soil type: clay loam over medium clay

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