Soil moisture monitoring for crop management

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Abstract. The 'Risk management through soil moisture monitoring' project has demonstrated the capability of current technology to remotely monitor and communicate real time soil moisture data. The project investigated whether capacitance probes would assist making informed pre- and in-crop decisions. Crop potential and cropping inputs are increasingly being subject to greater instability and uncertainty due to seasonal variability. In a targeted survey of those who received regular correspondence from the Department of Primary Industries it was found that i) 50% of the audience found the information generated relevant for them and less than 10% indicted with was not relevant; ii) 85% have improved their knowledge/ability to assess soil moisture compared to prior to the project, with the most used indicator of soil moisture still being rain fall records; and iii) 100% have indicated they will continue to use some form of the technology to monitor soil moisture levels in the future. It is hoped that continued access to this information will assist informed input decisions. This will minimise inputs in low decile years with a low soil moisture base and maximise yield potential in more favourable conditions based on soil moisture and positive seasonal forecasts

1. Introduction
There are limited examples of the use of soil moisture probes in a dryland cropping system in Victoria but increasing interest in the grains sector from both service providers and farmer groups. A scoping study conducted by the Department of Primary Industries (DEPI) on the focus groups of farmers involved in the projects nine monitoring sites and found that:

Soil moisture levels are estimated/measured by over 90% of the group and conducted by a number of methods, generally subjective. Most popular were estimations from recent rainfall events, crop condition, and drive by observations. Some were using self calibrated tools such as push probes and soil sampling and determining the wetness of soil. General feeling was that estimations could be improved on current methods and enough cases where they had got it wrong to explore alternatives.

Agronomists generally had a greater interest in soil moisture monitoring technology as a need to measure, when advising on critical business decisions. Benefits identified were with time efficient monitoring and the ability to compare previous year’s data. There were a very small percentage of farmers who were using volumetric sampling where millimetres of water could be calculated with some farmers using these measurements in modelling programs such as yield prophet.

A state-wide project across many rainfall districts and soil types, there are some differences identified by the groups of farmers with use of probes. In low rainfall zones, using soil moisture probes will aid the crop choice decisions by showing pre sowing plant available. Good soil moisture reserves also provides confidence to sow by the calendar. Higher rainfall zones with reliable winter rainfall, farmers will follow rotations as guided by Best Management Practices and not by soil
moisture reserves but knowing the soil moisture levels will allow strategic inputs through the growing season to target the potential high yields.

2. Material and Methods
Growers current cropping systems may not be maximising water use efficiency, if they are using subjective assessments. The practice of using moisture probes has had limited use in the grains industry and as such many farmers are unaware to utilise this technology. Moisture sensors and telemetry devices that use the mobile network to send the data to be securely stored on a server that is accessed with the internet. Farmer focus groups were generated based on recognized cropping regions and linked to local sites to assist in the validation of examining deep soil moisture and determining usefulness, usability, and availability. Participants were educated in interpretation of data, received regular email updates explaining recent soil water changes and had access to live data via a soil moisture graphing website.

3. Data Access
Access to this data enabled project participants -
- Observe deep soil moisture (30-100cm) at one representative point in a common soil type on a district farm
- Moisture displayed in absolute soil moisture content and with the iNTELLiGraph software, crop upper and lower limits under different soil types and crop types could be estimated.

4. Results
Over the three seasons of monitoring the project has built up knowledge of estimated crop upper and lower limits in different soil types across different crops. The seasons were quite extreme with at least one wet summer (some sites with two and floods). The majority of the growing seasons have been low decile and has seen a huge depletion of soil moisture reserves through late August to October. The value of sub-soil moisture has been clearly evident and participants have been amazed of the ability of crops to use moisture from 60cm and beyond and how quickly a large biomass crop will use moisture in spring. The following are examples of where this information could be used to assist in decision making in dryland cropping.

Site at Youanmite (North East Victoria), dotted red oval indicates the depletion of soil moisture reserves through Spring 2011 and the dashed blue oval represents the flooding rains in early March 2012 that refilled the profile. The star indicates the sowing time where the crop was planted with a good profile of deep moisture. The green shaded area is where plant moisture use has been observed, and the white area below is nearing crop lower limit and moisture stress. The black line is a summed total of soil water content from 30-100cm.
**Figure 1.** Accumulation of soil moisture through summer and autumn from a dry soil profile.

**Figure 2.** Summed soil moisture graph displaying plant water use through spring with high levels of plant available water.

Site at Raywood (Central Victoria), the red oval highlights the depletion of a near full profile of moisture recorded in July 2012 with a low decile spring. The level recorded in November was an estimated crop lower limit for that monitored soil type of clay loam.
Figure 3. Individual sensor stacked graph of the Raywood SMM site.

A zoomed view of the Raywood site of all the individual sensor depths (positioned every 10cm starting at 30cm to 100cm). Dotted ovals highlight the moisture use from the different soil depths. Early spring moisture is used from the easiest area of access being the shallow sensors while in late September moisture is being used from 60cm down to a meter. The dashed oval indicates that the sensors at that depth has reached crop lower limit with no change in the soil water content (flat line) during October. At this site with the dry spring, crop lower limit was reached down to one meter. (NB. separate sensor graphs are defined by colour and sensor lines are arranged as per depth location, shallowest on top and deepest on the bottom).

Figure 4. Varied water use through two spring periods associated with different levels of plant available water.
Summed soil moisture content from site at Speed (Mallee), dotted red oval highlights the depletion of a full profile of moisture in 2011 with a low decile spring. The soil moisture reserves were never built up to those levels again even after significant rain in July deposited moisture deep (dashed blue oval). Low moisture use in spring 2012 was attributed to crop vigour and limited plant available moisture.

5. Conclusions
The challenge to the grains sector is to increase productivity growth. This may be from a number of options, some of which include:
- Better farm decisions through improved information - not just more information
- Potentially through the uptake of new technology.

The soil moisture monitoring network has proven to successfully link to both of these with positive results. The challenge is Micro monitoring a site for paddock size management. Different soil types across paddock and farm and how many monitoring sites required versus the ability to vary paddock management.