Modern soil moisture monitoring for drought resilience.

The modern soil moisture monitoring for drought resilience is a development project designed to improve soil moisture monitoring adoption throughout Australia. Factors such as variability or change in the climate, greater demand in food resulting in a greater demand for water, improving profit margins, cuts in water allocation, and personal goals are all different reasons growers may look at the adoption of soil moisture monitoring.

There are benefits of becoming more drought resilient, but there is also huge upside potential for those that have not yet optimised their water or fertilizer use efficiency. Unfortunately, Barriers such as lack of awareness, over complication, costs, lack of support services and installation woes have been the forefront of low adoption rates.

Tips for installing soil moisture monitoring equipment.

Location, Location, Location!

Where are the best places to install your soil moisture monitoring equipment?

DON'T

- Install next to leaking irrigation.
- Diseased or poor growing trees (outliers).
- The outside rows of your irrigation block.
- Soil that has unique soil texture.

DO's

- An area that can represent the rest of your irrigation block.
- In a soil texture that is similar to the rest of your irrigation block.
- Place the sensor in the wetting area of your dripper/sprinkler.
- Know the water distribution of your sprinkler. If you haven't tested your sprinkler, then you might be surprised!

Installing moisture monitoring equipment

- **Know the depth you need!**
  Where are most of the roots in the soil? Knowing where the roots are is a good way to know what depth for the sensors.
- **Dig around and find out**
  Find out how soil texture can change in a small area and where most of the roots can be found depth wise and distance from the tree, try and prove yourself wrong before installation.
- **Soil contact is crucial**
  Good contact with the soil can be very important, gaps can allow water to run down the side of your probes and create misleading data. Good contact also gives you the best chance of clear and understandable information.

Taking advantage of services that can install the equipment can give you a head start in using the equipment and learning how to install the equipment yourself if you're a vegetable grower who needs to frequently re-install the equipment due to soil cultivation.

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Key points to improve your irrigation management:

- **Get your soil to field capacity.**
  - The more available moisture in the soil, the better your crop performs. (exceptions exist such as alternate irrigation for vineyards or during dormancy).
  - Steep declines in VWC (volumetric water content) after irrigation is drainage = field capacity has been reached.
- **Monitor your leeching.**
  - A little can be good for reducing salt in the soil.
  - Too much leeching can be a waste of water and fertilizer, nitrogen from urea applications, for example, will move with the water. Leeching can be very expensive!
  - The sandier the soil is, the easier it is to leech.
- **Monitor the rain you receive.**
  - Rain does not always get you to field capacity, growers usually overestimate the benefit of rain.
  - Big rain events can cause leeching, how does this impact your fertilizer applications?

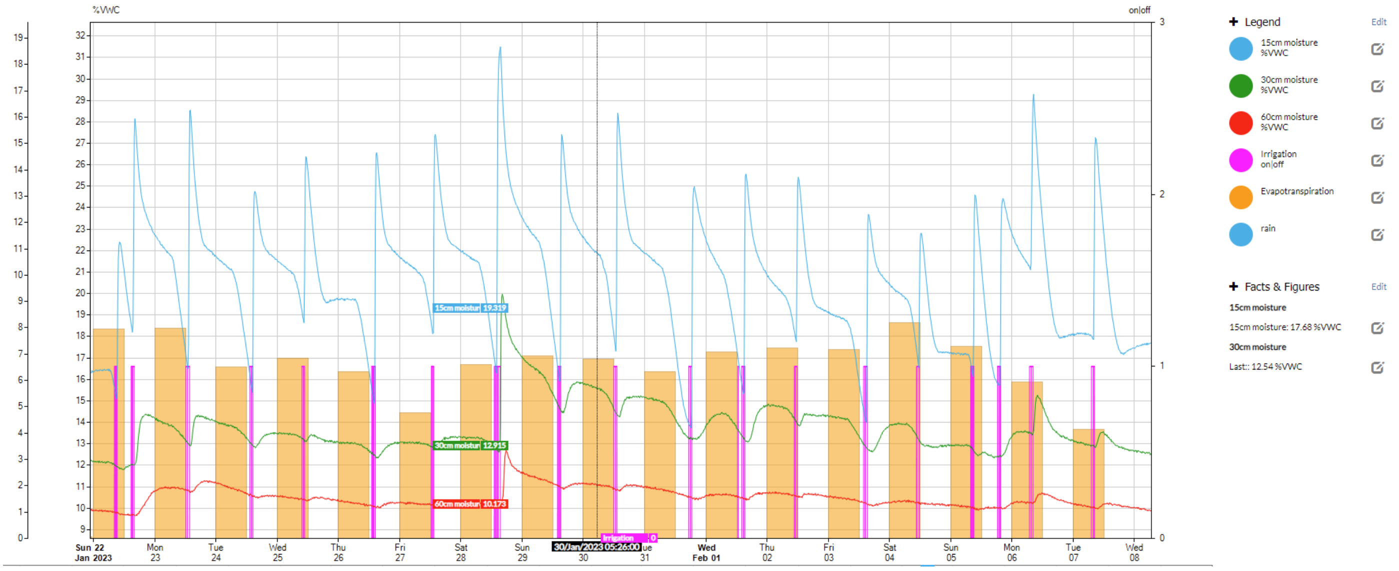

Figure 1Teros 12 sensor data from an avocado orchard in sandy soil in Yallingup.

Soil Moisture Graphs

The above figure is data coming from the Teros 12 soil moisture sensor installed in an avocado orchard with a sandy soil. Key points to take away from this information:

- The blue lines are the sensor at 15cm, green line is the sensor at 30cm and the red line at 60cm.
- The orange bars are evapotranspiration, there are blue bars for rain but there was no rain during this period.
- The pink lines are irrigation turning on and off.
- Over irrigation caused leeching on the 28th of January seen by the peak and steep decline in the red line.
- All irrigation events achieve field capacity in the topsoil. We can see this by the steep decline in the blue line, a sign of drainage occurring.

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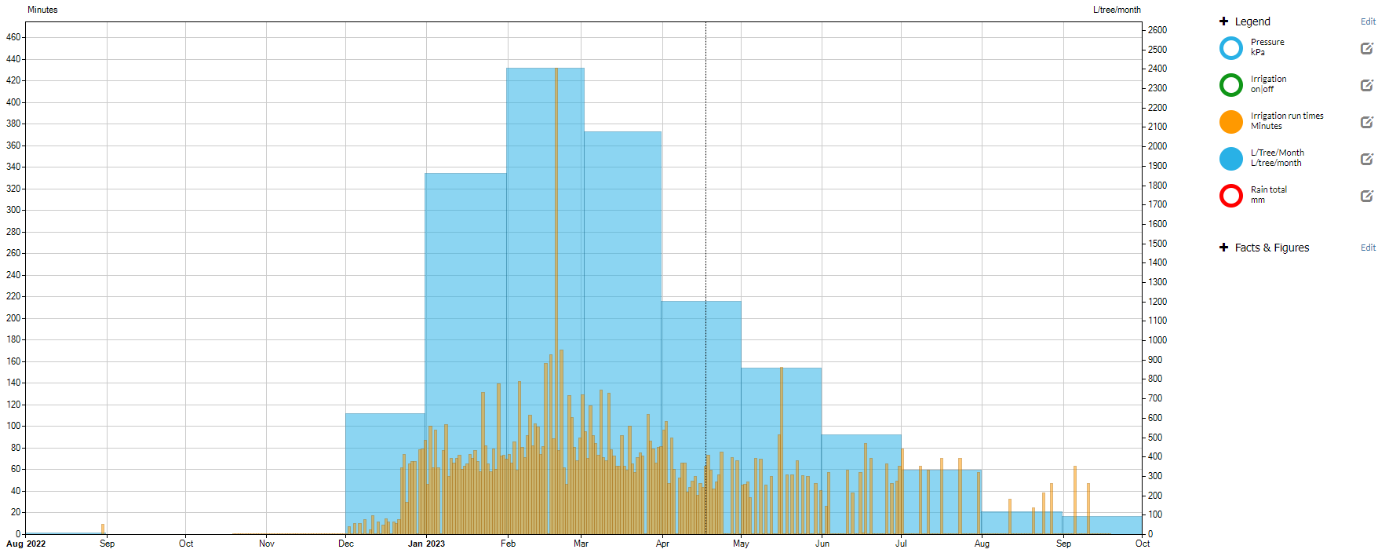

Figure 2. Pressure transducer data configured to show irrigation run time in minutes and litres per tree.

Pressure Transducer

The above figure is data from a pressure transducer located on the same avocado farm as figure 1.

A pressure transducer installed in the irrigation line will provide pressure readings, from that we can determine when and how long irrigation is occurring and record this. The information from the pressure transducer can be easily modified on a per month basis or per year/season. There is also a bar graph on the litres per tree. This information can assist growers with questions:

- How much water is required for the year?
- When will water be required the most in the season?
- Can the orchard be expanded without compromising water security?

Besides providing historical data for growers to analyse their water consumption, growers have found it helpful for:

- Confirming the irrigation event has happened if off farm.
- And tool for identifying if irrigation has not happened due to:
  - broken solenoids,
  - forgetting to manually water,
  - burst pipes,
  - and troubleshooting for irrigation controller issues.

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Irrigation and Crop Nutrition

Finding the irrigation volume

With a small modification the functionality of recording yearly irrigation volumes can be added to the soil moisture monitoring system. A pressure sensor installed inline by the soil moisture sensors monitors when the irrigation is on and off. With a simple equation this can be used to find the total irrigation volume.

$$Irrigation\,Volume\left(\frac{ML}{Ha}\right) = \frac{run\ time\ (hours) \times emitter\ output\ (L) \times emitters\ per\ Ha}{1000\,000}$$

Determining nutrient loads in irrigation water

All irrigation water will contain some nutrient ions. Even rainwater contains a measurable quantity of Ca, Mg, K, Na, Cl and S. This initial nutrient load is then concentrated by the evaporation of some of the rainfall. If the water runs through soil or rock it will pick up more ions, including N and P (which are uncommon in rainwater). The final nutrient load of the irrigation water once it hits the crop can often make a significant contribution to crop nutrition.

Sending off a water sample for analysis provides quantifiable values of the nutrient concentrations in irrigation water. This can then be multiplied by the irrigation rate to determine the total addition.

$$Addition\left(\frac{kg}{Ha}\right) = Concentration\ (ppm) \times Irrigation\,Volume\ (\frac{ML}{Ha})$$

The concentration of nutrients in the water will change over the course of the year, so the water sample should be taken during summer when the greatest volume of irrigation water will be used.

Rain and spring fed dams will often have S and Mg concentrations high enough that the total addition from irrigation will be in the tens of kilograms per year, which is a significant contribution given their relatively low requirement. Groundwater from shallow aquifers under intensive agricultural areas can also have N contents high enough to supply tens or even hundreds of kilograms of N to the irrigated crop.

Managing salt

Most growers manage salt additions from irrigation by adding periodic leaching irrigations, where a higher volume of irrigation water flushes the salts below the rooting zone.

Soil moisture sensors can have a secondary purpose of monitoring the salt content of the soils, which provides some quantitative data for the scheduling of leaching irrigations and for monitoring their effectiveness. The salinity data that is generated will come in one of two forms…

- **Bulk EC:** The total ability of the soil to pass an electric current, which is controlled by the clay content, water content and salt content of the soil.
- **Pore EC:** The ability of the soil water to pass an electric current. This is a relatively accurate proxy for the level of salt in the soil.

Bulk EC is the form directly measured by sensors, but it can be roughly converted into Pore EC by an equation, so long as the soil moisture and soil texture are known.

EC should be monitored by the sensor which is in the main rooting zone (normally the 10 or 15 cm sensor). If using Pore EC, the leaching irrigation can be triggered when a threshold is met, but the pattern of the graph will need to be used for interpreting bulk EC. Agronomic advice should be sought for help interpreting the salinity data generated.

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