Guide to Purchasing & Locating Soil Moisture Sensors

Before you purchase a soil moisture monitoring device you must first identify your requirements - this will guide your decision making in the type of equipment you purchase.

Many decisions to purchase soil moisture monitoring equipment are made on price alone and after a short period of use the equipment is abandoned – resulting in a wasted investment. This guide will help you choose a device that matches your management style, crop and situation, the amount of information you need, and your budget.

Before you buy a product answer each of these questions to ensure you choose what's right for you:

1. What information do I need from my soil moisture monitoring?
2. How labour intensive is it?
3. How user friendly is the information?
4. What level of accuracy do I need?
5. Does soil type affect my choice?
6. Does the irrigation system limit my choice?
7. Does crop type limit my choice?
8. What other site factors affect my choice?
9. How durable is the product?
10. How much maintenance will it need?
11. Can I afford it?
12. What are the next steps to take?

1. WHAT INFORMATION DO I NEED FROM SOIL MOISTURE MONITORING?

Soil moisture monitoring devices can provide a range of information. Some devices give simple 'wet/dry' measurements, which gives a basic guide to reducing plant stress and minimising irrigation water losses in the field. Other devices can gather more complex information:

- Depth and amount of irrigation,
- Root activity and development,
- Extent of water tables within or just below a crop's root zone,
- Irrigation timing and forecasting based on water use (known as irrigation scheduling),
- Soil temperature.

As a minimum you need the device to provide soil moisture readings for the plant root zone before and after an irrigation event. A reading following a rainfall event is also of benefit.

- The reading before an irrigation shows how dry the soil is.
- The reading after the irrigation or rainfall event shows how deep the moisture has gone, and can be used to indicate how much irrigation was applied and if under irrigation has occurred.
- A reading taken below the active root zone of a crop can indicate whether over-irrigation (drainage) has occurred.
- If you take additional readings between irrigation events you can determine your crops pattern of water use.

There are many devices on the market to determine the moisture content of the soil. They range in price, complexity, use and methods of data collection, and the detail of data provided.

2. HOW LABOUR INTENSIVE IS THE DEVICE?

Devices requiring the irrigator to collect information manually are more labour-intensive than devices that collect or log data automatically.

Labour availability is often not considered in the purchasing decision - but lack of time or labour is one of the main reasons why irrigators abandon manual monitoring.

Manually read devices need to be read regularly throughout the irrigation season. Missed readings result in incomplete data which is less useful. The benefit of the data is then compromised often resulting in the abandonment of monitoring mid season. The purchase cost is written off and the equipment, although sound, is left to gather dust!

If you purchase a manually read device, you have to commit the labour required to undertake the readings. If you cannot guarantee this labour commitment, then you should seriously consider other options such as **automatic logging devices** or a **contract service**.

Automatic logging devices can be downloaded periodically in the field or telemetry options can be

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added that automatically send the data via radio or mobile phone to your PC or a server for viewing over the internet. With many automatic devices the data can be viewed anywhere in the world as long as internet access is available.

3. HOW USER FRIENDLY IS THE INFORMATION?

The information from soil moisture monitoring devices is often most useful when presented as **graphs or charts,** this makes it easier to compare and interpret data.

Some devices come with software to view and interpret data on date/time, soil moisture value and depth of reading, or sometimes this software is available as an optional purchase. Most devices that are continuously logged come with software which converts and presents the data in a convenient format. For other products you may need to use spreadsheet software to work with the data.

You will need training in operating the device and interpreting and analysing the data. Check with the supplier whether training is provided, and to what degree? This should be detailed on a contract of some type to help ensure that back up is provided. Being unsure of how to make best use of the device is one of the key reasons why irrigators stop using monitoring equipment.

Try and choose a device where you can get ongoing support and software updates. This is a critical component of learning how the equipment works and learning what the data is showing and should continue until you are competent in its use. It is suggested that this be a requirement when selecting a device and company.

Often, especially initially, an agronomist will be useful as well in helping understand the soil, water and plant interactions. Are there grower support groups where results and other issues can be discussed?

Is any equipment needed to access and interpret the data (especially the data from electronic devices)? This equipment may be as simple as a pen and paper or as complex as mobile phone and/or telemetry and computers. Is the equipment included in the purchase? Can the data be printed or emailed?

Some companies offer a service where data can be fully managed by the supplier. The data is communicated via mobile phone technology to a remote server where it is housed and managed. The grower accesses this data via the internet. You need to understand how this works, if any upfront or ongoing costs are associated and how reliable the service is?

4. WHAT LEVEL OF ACCURACY DO I NEED?

The device needs a level of accuracy that matches your irrigation system and the degree of control it allows. For example, if your system is capable of delivering varying amounts of water precisely the device must be accurate enough to provide detailed and frequent soil moisture use information. You need less detailed information when system management is restricted (set rotations that only require stop/start decision making) or where water supply is restricted. But don't forget about the future aspirations for your property.

The level of accuracy of a device is not always related to cost. Correct installation is critical for accuracy. Also ask the question is the level of accuracy only a manufacturer's claim, or can it be supported?

Calibration: The device's ability to obtain consistent readings **(repeatability)** can be improved by **calibration**. Readings from the device are compared to independent measurement of soil moisture content. The method and need for calibration depends on the type of device. Calibration can also be used to determine a volumetric reading for the soil moisture (often given in mm).

5. DOES SOIL TYPE AFFECT MY CHOICE?

Soil type can affect which device you should choose, as some devices may be inaccurate in some **soil types**. For example, gypsum blocks in sands/gravels, and capacitance probes in cracking clays may give inaccurate readings.

Variations in soil type usually occur across the farm or paddock. You need to check that you have enough soil moisture monitoring sites to get representative data for the area being irrigated. As a minimum you should ensure the most representative soil type is covered. This is linked to the amount of funding you wish to commit and the level of precision you are trying to achieve. There is a trade off between the number of probes installed, the cost of the equipment and the accuracy or precision you require.

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6. DOES THE IRRIGATION SYSTEM LIMIT MY CHOICE?

The characteristics of the irrigation system should help determine what device is chosen and how it is installed. Surface irrigation may impede access for manual readings and may also cause problems by inundating sensors or access tubes, so waterproofing is important.

The **uniformity** (how evenly the water is applied) of a system affects how sensors may be placed. Drip and micro irrigation in particular require correct selection of representative monitoring sites. It is important that the spacing between the probe and the emitter or drip line is considered.

7. DOES CROP TYPE LIMIT MY CHOICE?

The profile and placement must match the requirements of the crop at the monitored site:

- Deep-rooted plants may need more sensors, or single sensors giving readings at multiple depths. It may be sensible to do a soil pit to identify the soil characteristics at different depths and any layers that may limit plant growth. This may help identify the ideal placement of sensors at multiple depths.
- For annual crops, sensors may have to be installed after emergence and removed at the end of the season before harvest.
- The machinery and human traffic in the crop affect how sensors can be placed. Lucerne is a particularly difficult crop to monitor because of the traffic during haymaking. Growers should consider above versus below surface probes depending on their situation.

8. WHAT OTHER FACTORS AFFECT MY CHOICE?

- The importance of probe installation cannot be overstated. There are many things that can influence the quality of data, installation being a key factor. Therefore it is critical that the installation of the probe is done by a qualified person.
- Livestock grazing on crops also affects how data can be collected.
- Reading sensors manually could damage some crops and compact the soil around the sensor site. Automatically logged devices maybe a better choice for these situations.
- How is the device powered? Is this power available, and can the power source be protected in the field or in transit?
- Soil Moisture Monitoring devices provide additional information that can help guide and improve irrigation decisions but they should always be used in conjunction with other tools such as weather data, field observations of the crop and soil moisture, shovel etc.

9. HOW DURABLE IS THE PRODUCT?

Both portable and permanent products need to be assessed for durability:

- Will the device stand up to damage from ultraviolet rays, moisture and extreme temperature?
- Livestock, pests and machinery traffic can damage fixed devices. Will water get into electronic parts, will the seals weather? What about lightning strikes?
- Portable products need to withstand possible damage in transport.
- Is it buried below the surface or will it require protection? If the latter additional labour will be required to ensure the area around the probe is representative of the crop in the field.
- If the product is damaged what back up support is provided by the company that supplied the equipment? Will they come out in the field and assess the damage? Can it be fixed on site or will it need to be removed and sent away to be repaired?

Ensure all these things are documented by the company before you purchase the equipment.

10. HOW MUCH MAINTENANCE WILL IT NEED?

Some devices may have particular maintenance needs or particular difficulties in servicing, and these have to be considered during your selection process.

- Look at mid-season and end of season maintenance requirements. Can you maintain it, or is dealer servicing required? Does it need to be sent away, and if so, how long for and who pays?
- Does the product come with adequate dealer support?
- If the product needs to be sent away, is a replacement product available?

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- What is the likely turn around for product repairs?
- Is the equipment “plug and play” (that is if you plug it in it will work without any additional configuration) or will in field configuration be required?

11. CAN I AFFORD IT?

In answering this question, assess both the initial and the annual costs.

Initial cost is usually the most important factor considered by irrigators when a product is purchased. Cheaper products tend to be manually read and so can be more labour-intensive. If labour can be provided easily and cost-effectively, this is not an issue.

Labour can be an issue if its cost over many seasons is considered. The cost of labour, mainly in data collection, can be quite high, as readings may need to be taken every two to three days at each site throughout the season.

It is important to look at methods such as the **automatic collection of data** as a means of reducing the labour cost of data collection. The trade-off is usually the increased initial purchase cost of the product, but in some cases, and on some crops, this may pay for itself relatively quickly.

The issue of **annual costs** relates to maintenance both during and after the season, and re-installation costs in annual crops. Here the variation in cost between products lies with differing labour requirements and the need for dealer or outside support.

Irrigators need to also consider the potential water saving and productivity gains that may accompany the use of the equipment. However, these benefits will only be achieved if the grower understands the equipment and its limitations, uses the equipment appropriately and interprets the information correctly.

12. WHAT ARE MY NEXT STEPS?

- ✓ Before any purchase, it is recommended you consider the points covered and make time to talk to:
  - irrigators who have successfully used the product that you are considering,
  - irrigators that have tried the equipment but no longer use it,
  - a range of equipment suppliers.
- ✓ Consider what level of scheduling you want to undertake?
- ✓ Match the device to your enterprise and your management style?
- ✓ Make sure adequate labour is available to read manual devices regularly: if labour isn't available, consider automatically read devices, or contractors.

Tips on Placing Moisture Sensors

- Install sensors in average soil and slope areas.
- Avoid field edges and unusually wet or dry areas.
- For tree and vine crops, place sensors away from the trunk but inside the canopy drip line.
- The question of where to install soil moisture sensors is a management decision, depending on crop rooting depth and growth stage, soil conditions, and other factors. In general, though, management should focus on the effective root zone - the upper half, where plants take up most of their water.
- For deep rooted plants in deep soils (>0.60 metre) place sensors/take readings at a minimum of three depths - the top, middle, and deepest third of the total root depth.
- For shallower rooted crops (<0.60 metre) place sensors/take readings at a minimum of at two depths.
- It is useful to place a sensor/take readings below the root zone – particularly for shallow-rooted crops (including grasses), or in the lower quarter of the root zone for deeper-rooted crops, as a way of detecting deep percolation and overwatering.
- For centre pivots, monitor a few sprinkler diameters from where you normally start the pivot, in the direction of pivot movement. Also monitor a few sprinkler diameters before the spot where you normally stop the pivot.
- Avoid the inner part of a pivot circle (inside the first tower), which tends to be wetter than the rest of the circle.

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Method	Instruments	Basic Principles	Advantages	Disadvantages
Soil Based Measurements				
Appearance & Feel	Hand and/or probe	Wetter soil is darker, physical properties change.	Simple - no special equipment.	Unreliable, poor accuracy and time consuming. Yield loss and water wastage likely.
Gravimetric Analysis (wet and dry weight)	Oven and accurate weighing equipment	Difference in weight of soil sample before and after drying show actual water content.	Direct measurement of soil water content. Very simple.	Require multiple samples, takes 24 hours to dry sample - plants may be stressed in mean time. Not real-time.
Soil Matric Potential (soil suction)	Tensiometers (Irrometer, Quickdraw)	Soil suction increases as it dries - tension measures how hard it is for plants to draw water.	Measures water tension directly. Close correlation to plant 'experience'. Can be automated.	Multiple sites, careful installation, frequent readings and maintenance.
Electrical Resistance (soil conductivity)	Gypsum Blocks (Watermark sensor)	Electrical conductivity increases with water content -drier soil has greater electrical resistance.	Indirect measure of soil water content. Easy automatically record / monitor. Same units as soil suction	Multiple sites, careful installation, calibration and frequent readings. Can be affected by soil texture.
Electromagnetic Capacitance	Time Domain Reflectometry - TDR (ECHO, Aquaflex, Diviner)	Water content controls the speed of an electromagnetic pulse sent through the soil.	Accurate, quick measurement of soil water content. Probes cheap, permanent, no servicing required.	Control unit very expensive. Multiple sites, probe/tube installation and interpretation.
Neutron Scattering	Neutron probe (Troxler)	Emitted neutrons slowed by hydrogen atoms in water molecules. Number slow neutrons = water volume.	Precise measurement of soil water content by percentage.	Very expensive, radioactive, multiple sites, tube installation, calibration and interpretation.
Plant Based Measurements				
Appearance	Eye	Plants start to wilt - subtle colour change.	Simple - no equipment needed	Yield lost before symptoms seen!
Leaf Temperature (Infra-red image)	Non-contacting thermometer	Transpiration reduces decreasing cooling and plant leaf tissue heats up.	Simple - relates to plant stress. Allows remote sensing	Techniques not well developed.
Leaf Water Potential	Pressure chamber	Measures plant hydration, a combined effect of aerial and soil environment.	Correlated to plant metabolic processes.	Large day/night variation, expensive, time consuming, difficult interpretation.
Atmospheric Measurements				
Pan Evaporation Rate	Evaporation pan	Water loss from a free water surface correlated to soil evaporation and plant water use.	Simple, cheap. One site can serve large area	Requires frequent service and data collection, careful siting, calibration for each crop and canopy size
Soil Water Balance Calculations (soil, climate and crop data)	Water balance models (manual calculations or sophisticated plant growth models)	Potential evapo-transpiration (from climate data) adjusted by crop coefficient (reflects crop/growth stage). Soil-water balance calculation updated on a daily basis.	Well developed, one calculation can serve a large area. Accurate for most crops over longer term. Good guide.	Requires considerable data and calculations, (manual calculation difficult for crop/growth stage. May not account for extreme conditions (strong, dry wind) in the short term.