Soil Moisture Monitoring

Choosing the right device

This information has been developed for irrigators who are considering the purchase of soil moisture monitoring devices that aid decisions relating to irrigation scheduling.

Best management practice in irrigation includes regularly monitoring soil moisture levels throughout the irrigation season. DPI encourages farmers to adopt and use long term soil moisture monitoring to help achieve optimum water use and maximise crop yields and quality.

It is strongly recommend that before you purchase any soil moisture monitoring device you identify your individual requirements, this will help guide your decision in relation to the type of equipment you purchase.

Sadly, too many decisions to purchase soil moisture monitoring equipment are made on price alone. After a short period of use the equipment is abandoned, a wasted investment and a poor advertisement for soil moisture monitoring.

This information help you choose a device that matches your management style, crop and situation, the amount of information you need, and your budget.

Don't buy a device until you answer each of these questions for your enterprise:

1. What information do I need from a soil moisture monitoring device?
2. How labour intensive is the device?
3. How useable is the information from the device?
4. What level of accuracy do I need?
5. Does soil type affect my choice?
6. Does the irrigation system I use limit my choice?
7. Does crop type limit my choice of device?
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 A SOIL MOISTURE MONITORING DEVICE?

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 watertables within or just below a crop's root zone,
- Irrigation timing and forecasting based on water use (known as irrigation scheduling),
- Movement of solutes (salts) through the soil profile,
- 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 was applied and if under irrigation has occurred (ie moisture has not penetrated deep enough into the soil profile where active root growth is known to exist).
- A reading taken below the active root zone of a crop can indicate whether over-irrigation has occurred.
- If you take additional readings between irrigation events you can determine a pattern of water use.

There are many devices on the market that in some way 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 usually the least considered factor in the purchasing decision but lack of time or labour may be important reasons why irrigators abandon manual monitoring.

Manually read devices need to be read regularly throughout an irrigation season. Any missed readings result in incomplete data, which makes the data far less useful. The irrigator may then assume there is no benefit in collecting data, and abandons the monitoring operations mid season. The purchase cost is written off and the equipment, although sound, is left to gather dust.

If you choose to 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 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 added that automatically send the data via radio or mobile phone technology to the growers 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 USABLE IS INFORMATION FROM THE DEVICE?

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 comprehensive software which converts the data and presents this information 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 SMM 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.

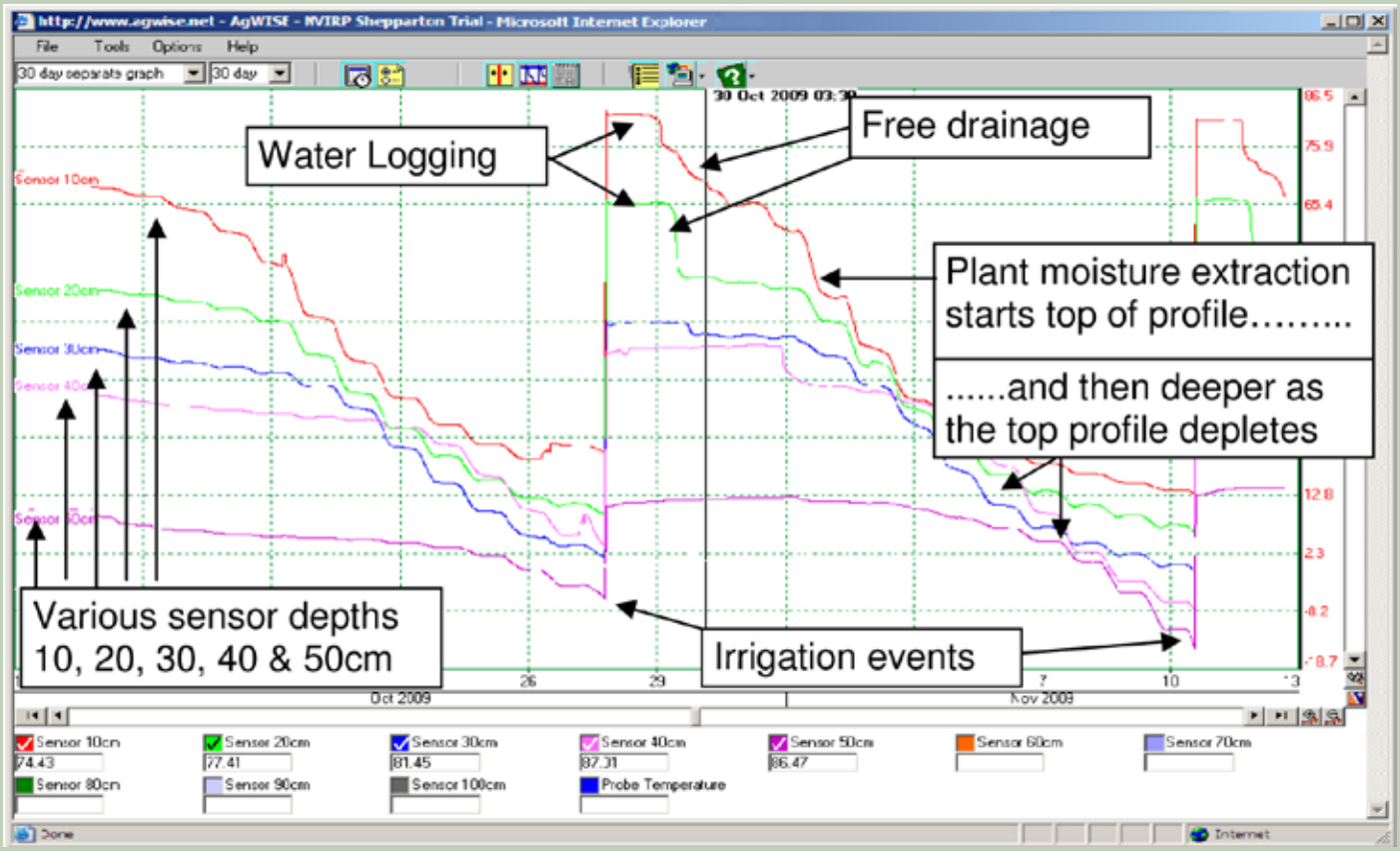
Often, especially initially, an agronomist will be useful as well in helping understand the soil, water and plant interactions.

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.

An irrigator accesses in field soil moisture status remotely via the internet



Separate level soil moisture graph for a perennial pasture site

4. WHAT LEVEL OF ACCURACY DO I NEED?

The selected device needs to have 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 you choose should be accurate enough to provide detailed and frequent soil moisture use information. You need less detail when system management is more basic or where water supply is restricted. But don't forget about the future aspirations for your property, a whole farm plan will help you document these in a planned and coordinated way. Depending on how long it will be before you implement these plans it may be worth considering equipment that will suit the modernised property.

The level of accuracy of a device is not always related to cost, and some low-cost devices are quite accurate. Note that "hand-feel" soil moisture assessment will not be as accurate as a device which directly and repeatedly measures soil moisture content. Correct installation is critical for accuracy.

Is the level of accuracy only a manufacturer's claim, can it be supported?

Calibration:
The device's ability to obtain consistent readings every time (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 OF DEVICE?

Soil type can affect which device you should choose, as some devices may be inaccurate in some soil types. For example, gypsum blocks in sand and capacitance probes in cracking clays may give inaccurate readings. Salinity may also affect the accuracy of some sensors.

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 at that time. 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 to this type of equipment and the level of precision you are trying to achieve. There is a trade off between the number of probes installed (how representative the data is), the cost of the equipment and the accuracy or precision you require.

6. DOES THE IRRIGATION SYSTEM I USE 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 distribution uniformity 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 OF DEVICE?

The profile and placement of the device 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.

DPI Project Manager Dale Boyd discusses soil moisture with an irrigator

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, for example, or 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 mechanical protection in which case 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 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? Back-up service is crucial. If the product needs to be sent away, is a replacement product available? 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 of a product.

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, then this will not be an issue.

Labour can be an issue if its true 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.

Growers 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.

There are suppliers that allow products to be rented for a period of time such as the growing season. This may offer an alternative for irrigators that don't want to buy the equipment outright or have short term crops.

A typical in field soil moisture data logger and telemetry system

12. WHAT ARE MY NEXT STEPS?

- Before any purchase, it is recommended you consider the points covered in this Agnote and make time to talk to:
  - irrigators who have successfully used the product or products that you are considering,
  - irrigators that have tried the equipment but no longer use it,
  - as many equipment suppliers as possible,
  - an Extension Officer from DPI.
- Consider doing an irrigation management course, such as the free Irrigation and Risk Management course offered by DPI. This course covers topics such as soil characteristics, soil/water/plant relationships, irrigation system performance, irrigation layout advice, crop/forage mixes, alternative irrigation systems and water trade.
- 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.

Further References

This document is an update of:

Williams, D. (July 2002) — Soil Water Monitoring: Choosing the Right Device (Agfact AC.27). NSW Agriculture.

For more detailed information on Soil Water Monitoring we suggest:

Charlesworth, P. (2005) — Soil Water Monitoring an Information Package, Irrigation Insights No. 1, Second Edition. CSIRO/CRC Irrigation Futures. ISBN 1 920 860 56 8 (print), 1 920 860 57 6 (online).

Soil moisture monitoring has seen many changes since these reports were written. They are a good guideline but growers should be encouraged to seek up to date information.

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DPI Project Manager Brian Holmes discusses soil moisture with an irrigator

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