SOIL MOISTURE SENSORS
April 2023

USING SENSORS TO IMPROVE WATER MANAGEMENT IN HORTICULTURE

SOIL BASED MOISTURE SENSORS

Soil moisture sensors can help optimise irrigation management, which can increase profitability by improving yield and quality, and reduce inputs. Using soil moisture monitoring tools can also reduce off-farm environmental impacts by decreasing the volume of leached nutrients.

For soil moisture sensors to be effective, they must be correctly installed, data checked and used in combination with other management information.

There are two types of soil moisture sensors commonly used:

1. **Time domain reflectometry (TDR)** sensors are very accurate, do not require calibration and are good for longer-term installations. Difficult and time consuming to install below 50cm depth.
2. **Capacitance** sensors are accurate if calibrated correctly and disturb less soil during installation. Good for quick installations and deep soil measurements.

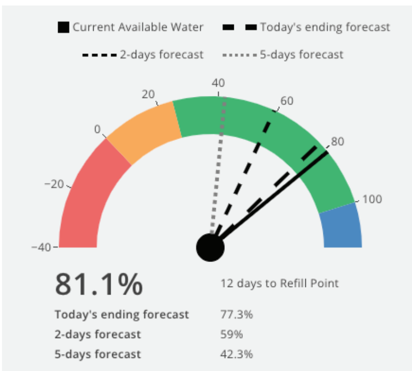
INSTALLING THE SENSOR

Key points when installing a soil moisture sensor (specific instructions should be provided in the sensor manufacturer's installation guide):

- Ensure sensors are installed in an area which is typical for the crop to optimise irrigation for this area
- Avoid field edges and wet or dry areas, unless you are specifically trying to manage these areas
- Use your knowledge of the paddock, aerial photos, satellite imagery and soil maps to help locate the right area

KEY POINTS IN SELECTING A SOIL MOISTURE SENSOR:

- Choose a sensor that is compatible with your data management system and can provide automatic readings in near real time and communicate data to the cloud
- Ensure local support is available for timely servicing; sensors are not set and forget
- Consider costs, both upfront and ongoing, for example, any subscriptions for communications
- Ensure the sensor can be buried at suitable depths for your crop
- Confirm the ease of installation and extraction when sensors are used in annual crops
- Confirm that the installation does not interfere with farm operations
- Consider the soil volume measured by the sensor; the bigger the better



Soil moisture data visualised on the Hitachi Control Tower

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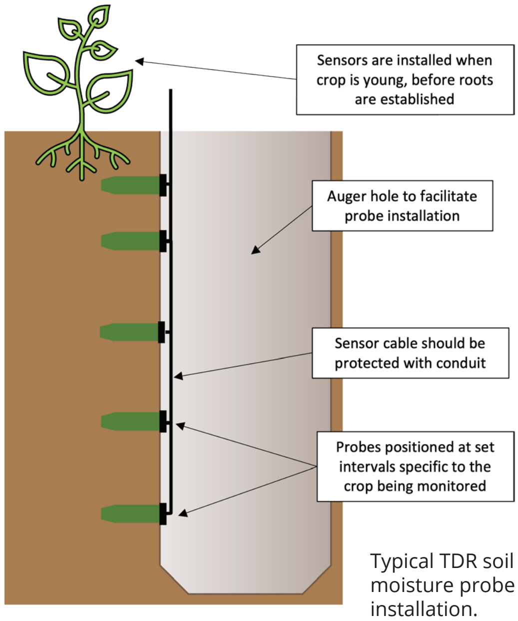

Typical TDR soil moisture probe installation.

- Note that a sensor located within a row will be influenced by the irrigation system and crop
- Determine the number of sensors required and placement depth of probes by examining the crop and soil conditions
- Place a sensor below the root zone to monitor water movement at depth and potential nutrient leaching

MANAGING THE DATA

Soil moisture sensors typically take a reading of the Volumetric Water Content (VWC%) around the probe every 30 minutes. For example, after irrigation, soil may have a VWC of 35%, which means that in the volume of soil measured around the probe, 35% is water and the other 65% is soil (60%) and air (5%).

For water budgets, VWC is converted into mm of water held in the soil. This is based on the VWC for each sensor and the depth of soil covered by that sensor.

This is calculated using the following formula:

VWC x soil depth = mm of water per depth of soil.

Soil types

Soil type has a major effect on how much water is held by the soil and available to the plant. In horticulture, to produce high yields only a small part of water held in the soil can be used by the plant. If the soil dries beyond this readily available water level, then plant growth and yield is usually reduced.

Setting full and refill points

Setting full and refill points is both a science and an art. Use Table 1 as a guide to initially set full and refill points. For example, for a sandy loam soil expect a VWC of 30% at full point and set a refill point at 25%, in 50cm of soil the soil will have 150mm of water at the full point and 125mm at the refill point. As a result,

Saturation (very wet): refers to a soil's water content when all pore spaces in the soil are filled with water. Typically, this happens after heavy rain. When the soil is fully saturated, no more water can be stored in the soil. Saturated soils do not stay full of wate r for long; typically 24 hours after the rain stops, water held loosely in the soil will drain out leaving the soil at full point.

Readily Available Water (RAW): the water that a plant can easily extract from the soil. RAW is the soil moisture held between field capacity and a nominated refill point for unrestricted growth.

Full Point (wet; field capacity): As much water as the soil can hold, 2 or 3 days after heavy rainfall, when the soil is fully saturated. At this point, there is very little downward movement of soil water due to gravity and very little suction due to capillary action.

Refill Point (moist): The refill point is the irrigation trigger point. Typically, this is set when all the RAW has been used by the plant. Beyond this point, the plant must work harder to extract water, reducing potential yield.

Wilting Point (very dry): The amount of water remaining in the soil when the plant wilts in a humid atmosphere. The water remaining in the soil is held tightly by soil particles, and plant roots cannot easily extract water.

Plant Available Soil Water: The amount of water in the soil between field capacity and the permanent wilting point.

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there is 25mm of readily plant available water. You now have a full and refill point that can guide your irrigation decisions, including when to irrigate and how much.

For more information see the smart farming technology guide for horticulture.

POTTING MEDIA BASED MOISTURE SENSORS

Much of the information in the moisture sensors (soil based) section is also relevant for potting media installations. Coir potting media is compatible with TDR soil moisture sensors; however, this is not the case with all potting media types.

For potting media moisture sensors to be effective, they must be correctly installed, data checked and used in combination with other management information.

INSTALLING THE SENSOR

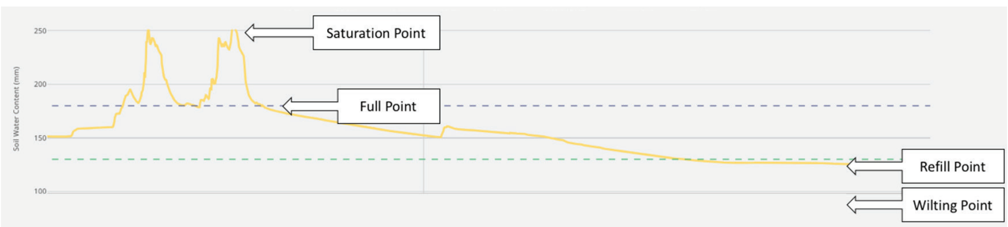
- Key points when installing a potting media moisture sensor (specific instructions should be provided in the sensor manufacturer's installation guide):
- Select a plant/container or group of containers in the irrigation zone that represents the irrigation requirements of the crop
- Ensure the representative container is in the middle of the crop and away from external influences, such as overspray from other irrigation zones
- Ensure that the container is not in an unusually shaded area, or on the edge of the irrigation zone that is affected by high temperatures
- Cut the side of the container to fit the head of the sensor, or drill holes in the side of the container and insert the sensor probes directly into the growing media; the sensor may need to be secured in place using cable ties to reduce probe movement.

NOTE: for some soil moisture sensors a specific calibration for organic growing media may be needed to account for the high air-filled porosity. Check the sensor manufacturer's instruction booklet for calibration requirements.

MANAGING THE DATA

Containerised nursery production and protected cropping production use a variety of organic growing media blends that have been engineered to perform in a container to optimise the root zone environment for plants.

Soil texture	Full point % VWC	Refill Point %VWC	Readily Available water % VWC	Full point mm/50cm	Refill Point mm/50cm	Readily Available water mm/50cm
Coarse sand	10	8	2	50	40	10
Sand	20	16	4	100	80	20
Sandy Loam	30	25	5	150	125	25
Sandy Clay Loam	29	24	5	145	120	25
Clay Loam	40	37	3	200	185	15
Silty Clay Loam	48	44	4	240	220	20
Light Medium Clay	38	35	3	190	175	15
Medium Clay	41	38	3	205	190	15
Heavy Clay	47	44	3	235	220	15



Annotated soil moisture data

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These organic growing media can be a single material or a combination of materials, such as coir, pine bark, perlite, vermiculite, zeolite, sphagnum peat, or rockwool.

The water holding capacity (WHC), air-filled porosity (AFP), and wettability will vary with the type of medium used or percentage of each ingredient used in a blend.

Coir (coco peat, coir fibre pith or coconut fibre derived from the husk of the coconut) is often the main ingredient in growing media blends as it is a sustainable and renewable resource.

TDR moisture probes inserted into a plastic container

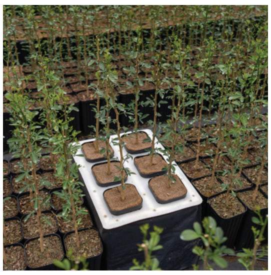
The average water holding capacity of a coir growing media is 40%, but this can increase with different blend combinations. Physical properties will vary according to the blend. A water holding content test is required for each growing media blend to determine the wilting point and container capacity by volume.

WEIGHT BASED MONITORING

Weight based irrigation management is useful when traditional soil moisture probes cannot be used, for example, if the container is too small or the growing medium is not compatible with soil moisture sensors.

Trends observable in weight graphs are similar to those in soil moisture graphs, with the same diurnal fluctuations. However, units of measurement will be different. A weight-based monitoring system uses load cells to measure container weight and can be calibrated to estimate water content from container capacity.

A set of load cells can be positioned within a nursery to provide accurate water content measurements. If properly configured, irrigation controllers can be triggered to irrigate when containers reach a set minimum weight and stop when a target weight is reached.



Weight based potting media moisture monitoring system

INSTALLING THE SENSOR

- Select a plant/container or group of containers in the irrigation zone that represents the irrigation requirements of the crop.
- Ensure the total weight of the saturated containers does not exceed the capacity of the load cell or weight scale.
- The load cell and representative plant should be in the middle of the crop and away from external influences, such as overspray from other irrigation zones, in an unusually shaded area, or on the edge of the irrigation zone where there may be high temperatures.
- Provide sufficient space around the weight scale to ensure adjacent plants are not touching the scale and influencing the readings.

MANAGING THE DATA

The graphs and trends provided by weight-based monitoring data are largely the same as those from soil moisture data. The same diurnal steps are identifiable as the plant transpires during the day, before transpiration slows down overnight. Irrigation events can be identified through a rapid increase in plant weight.

An increase in container weight is related to the length of the irrigation or rain event. A large increase in weight indicates a long irrigation or heavy rainfall, whereas a small increase in weight indicates a short irrigation or rain shower.

Water loss in grams per container size

Container Size (mm)	Weight loss (g) for 1mm of water
80	5
100	10
150	20
170	25
200	30
250	50
300	70

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