



Measuring soil moisture: From spade to sensors



FACTSHEET

Moisture only helps a tree if it's in the active root zone

1. Soil moisture

Measuring soil moisture helps growers make better irrigation decisions and avoid both dry stress and over-watering.

Monitoring can reduce water wastage, cut pumping and energy costs, and lower nutrient leaching risk.

Methods range from simple field checks to automated systems. At the entry level, visual and feel assessments are backed up with manual tools such as tensiometers and resistance blocks, giving repeatable readings at set depths.

More advanced options include multi-depth probes with data logging and telemetry that sends results to a phone or dashboard, reducing site visits and supporting decisions across multiple blocks.

Whatever the technology, start with a spade: it shows where roots are, how deep water moves after irrigation or rain, and how evenly the zone dries.

2. Start with a spade

Before buying any equipment, use a spade to learn how your soil wets up and dries down.

What to do

- Pick 2–3 representative sites in a block (e.g. a stronger area, a weaker area, and a mid-block area)
- Dig to 20–30 cm first. If the soil is dry at the surface, keep going down in 10–20 cm steps until you reach moist soil
- Squeeze a handful:
 - ◇ falls apart and feels dusty = **DRY**
 - ◇ holds together but crumbles easily = **MID-RANGE**
 - ◇ makes a ball and smears easily = **WET**

After an irrigation or rainfall, repeat the check to see how deep water actually reached.

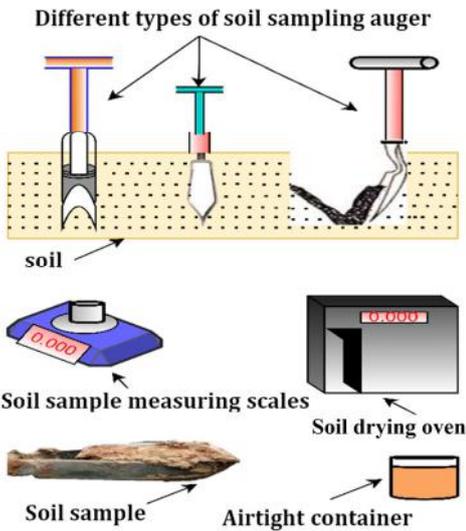
A spade quickly shows if you are wetting too shallow (roots stay near the surface) or pushing water past the root zone (water and nutrients move below where trees can use them).



Spade-and-hand soil check: squeeze a handful from the root zone to gauge moisture and structure in the field.
(Image: Rawpixel CCO_1.0)

3. Soil sampling

Gravimetric soil sampling (collect soil, oven-dry, and calculate moisture content) is very accurate but time-consuming and labour intensive, so it is rarely used for routine orchard decisions.



They can provide near real-time readings when installed at more than one depth, but they do require ongoing upkeep (checking water levels, maintaining good contact, and servicing) and have a limited effective range in drier soils.

2. Gypsum blocks

Gypsum blocks are a low cost option that can work well in finer-textured soils such as clays.

They estimate moisture via electrical resistance.

Their practical limits are lifespan and reliability over time, particularly if conditions are harsh or if blocks degrade.



Digital soil water potential sensors comprise a moisture content sensor and a porous substrate with a known moisture release curve. (Image: Edaphic Scientific. With Permission)

They operate across a wide wet-to-dry range and record data automatically. Most units are sealed and durable, need little ongoing servicing, and suit permanent installation at key root-zone depths.

They can connect to telemetry and IoT platforms via modems or LoRaWAN, enabling continuous logging, remote access, and alerts without regular site visits.

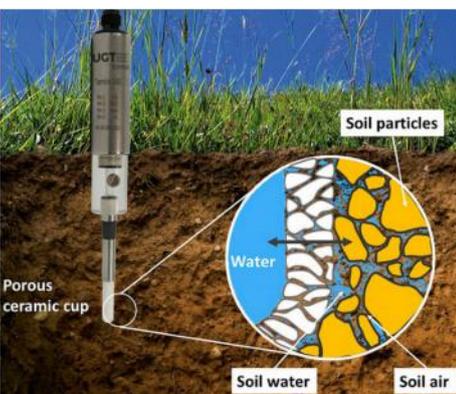
Used alone or with probes, they help time irrigations more effectively.

4. Manual meters

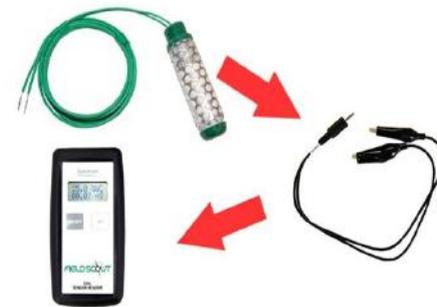
1. Tensiometers

Tensiometers measure soil water tension (how tightly water is held).

They are relatively low cost and suit coarser soils such as sandy loams.



Tensiometers measure the pressure ("tension") under which the soil water is standing. Tension is closely related to soil moisture. The drier a soil is, the higher the tension. (Graphic: UGT - The Solutionists. With permission)



This gypsum block can be read with a handheld meter. Gypsum blocks measure soil water potential between 0 and -200 kPa which covers the optimal range of soil moisture for nut trees. (Image: Edaphic Scientific. With permission)

3. Soil water potential sensors

Digital soil water potential sensors (for example TERSO 21) measure how tightly water is held in the soil and, therefore, how hard roots must work to extract it.

This provides a practical plant-available water signal that is easier to compare across seasons and soil types than many moisture content readings.

4. Where these fit

Manual meters fit as a low-cost, practical entry point for monitoring soil moisture, particularly in smaller orchards or where budgets are tight.

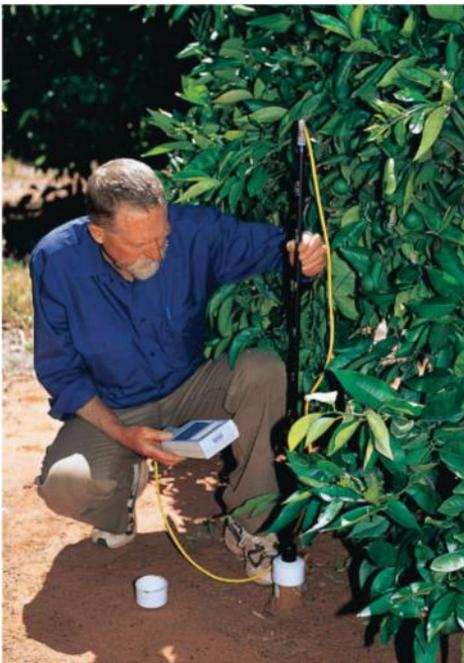
They are useful for learning how soils respond to irrigation and rainfall and for checking problem areas. The trade-off is time: readings require regular site visits and recording.

5. Probes

More advanced options include soil moisture probes which measure moisture at multiple depths and provide continuous logging with remote access via a phone or dashboard.

1. Capacitance probes

Capacitance probes measure soil water content by detecting changes in the soil's dielectric properties as moisture rises and falls.



Capacitance probes provide a convenient and relatively low cost instrument for measuring soil moisture level. (Image: © State of New South Wales CC_BY_4.0)

They can be accurate when installed well and used consistently, and most record multiple depths in one access tube.

Probes are often installed to about 80–120 cm to show wetting and drying through the root zone. Data can be logged and sent wirelessly to a phone or dashboard.

2. Time Domain Reflectometry (TDR)

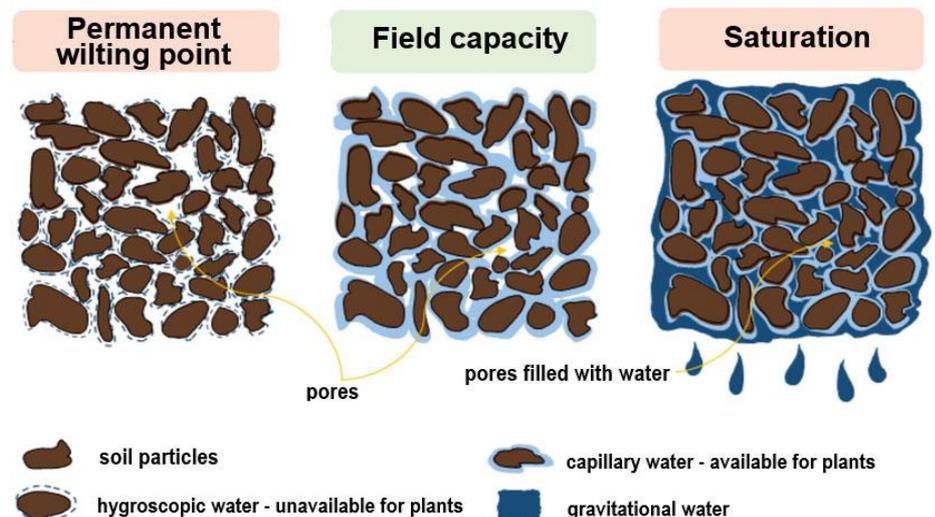
TDR measures the travel time of an electromagnetic pulse through soil, which relates to moisture content. It is reliable and can monitor different depths, but the equipment is usually more expensive than tensiometers or gypsum blocks.



After capacitance, TDR is perhaps the most widely used soil water content measurement technique. (Image: Edaphic Scientific. With permission)

3. Where these fit

Soil probes (capacitance or TDR) measure soil water content at several depths, showing how far irrigation water moves, how quickly layers dry, and whether water is draining below the active root zone.



Soil water content at saturation, field capacity and permanent wilting point. (Image: Datta et al. (2017) CC_BY_4.0)

TEROS-21 measures soil water potential, which reflects how hard roots must work to extract water and gives a clear signal of water availability to the tree.

Used together, probes help you place water in the right part of the profile, and water potential sensors help you time irrigations across different soils and seasons.

6. Key moisture terms

Before using readings to manage your irrigation, two terms help: **field capacity** (soil water after drainage) and **refill point** (when roots struggle to extract water).

- **Field capacity** is the amount of water the soil holds after excess water has drained following irrigation or rain.
- **The refill point** is the moisture level at which the soil becomes dry enough that trees can no longer extract water readily.

These two points define the practical operating range for monitoring.

7. Turning readings into decisions

Once you know your field capacity and refill point, use your readings to keep the active root zone within that operating band, rather than swinging between too wet and too dry.

Deep-rooted nut orchards can draw water from deeper layers (walnuts, for example, can have roots reaching down to around 1.8 m).

Tracking moisture at more than one depth helps you see whether water is staying in the upper layers or moving deeper, and whether deeper layers are still providing a buffer.

8. Getting started with meters or probes

Step 1: Pick your first block and your first sites

Start with one representative block, not the whole farm. Choose 2–3 monitoring sites:

- one typical area
- one lighter or fast-drying area
- one heavier or slower-draining area

Step 2: Choose a tool matching your soil and scale

1. Coarser soils and smaller budgets: **tensiometers**
2. Finer soils and low-cost monitoring: **gypsum blocks**

3. Larger orchards, variable soils, or limited labour: **capacitance probes or TDR**

Step 3: Decide depths before you install

Use your spade checks to see where roots and moisture sit.

Install at two depths to start (a shallow depth where feeder roots are common, and a deeper depth that shows drainage and deeper buffering).

If you use a multi-depth probe, set the sensors to span your typical root zone.

Step 4: Ground-truth for the first month

For the first few irrigation events and rainfall events:

- Compare sensor readings with a spade check near the sensor.

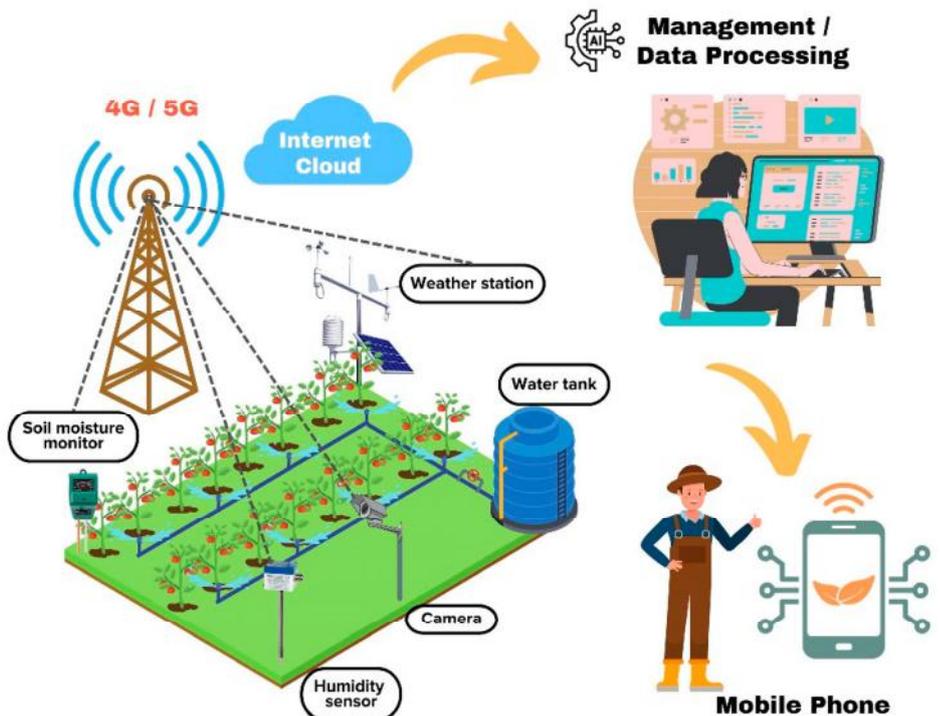
This helps confirm the sensor is placed correctly and that readings match what you see in the soil.

Step 5: Automate workflow

Automated systems transmit data wirelessly for continuous tracking, which can reduce manual labour and free up time for other orchard tasks.

A simple setup is:

- one dashboard (phone or computer)
- a short weekly review of trends
- alerts when the profile approaches your refill point.



Connected orchard monitoring system using 4G/5G: soil moisture sensors, humidity sensors, a weather station and cameras send data via the internet cloud to a management platform for processing and decision support, with key alerts and dashboards delivered to a grower's mobile phone for remote, real-time oversight of irrigation and orchard conditions. (Image: Ali, Hussain & Zahid (2025), AgriEngineering 7(4):106, <https://doi.org/10.3390/agriengineering7040106>, CC BY 4.0.)



Australian Government
Department of Agriculture,
Water and the Environment

This project is funded by the Australian Government's Natural Heritage Trust