Irrigation Management:

Soil moisture monitoring

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making useful things happen

Knowing when to turn the tap on, and when to turn it off, are critical issues in irrigation management. In my experience, growers make these decisions in three main ways. They watch the plants, they kick the dirt, or they have a guess ('gut feel' is commonly reported).

With a little science added, these key indicators can be very helpful in guiding our irrigation scheduling decisions. Let's think about them one at a time.

Watching the plants

By the time a grower can see wilting or other stress symptoms, plants are in serious deficit. Crop quality and yield will already be compromised. Plant based measurements can assess status well before visual symptoms are apparent.

Pressure bombs and infra-red thermometers assess how thirsty the plant is feeling. Sap flow monitors measure plant water use.

Pressure bombs measure how much force is required to drive moisture back out the leaf stem. This is a measure of leaf water potential, effectively how droughted the plant is. This varies throughout the day as transpiration rates change, peaking in the early afternoon.

Infra-red thermometers assess leaf surface temperature. If the leaf is actively transpiring, the evaporative cooling will drop the leaf tissue temperature. A stressed (non-transpiring) leaf will heat up, indicating water is required.

Sap flow monitors measure the speed of water movement up the stem. Their needles pulse heat into the sap, and measure the time it takes to travel up the stem. Done correctly, it gives a measurement of actual plant water use.

In some conditions, transpiration demand simply exceeds the ability of the plant to keep up. The plant can shut down, even though soil moisture levels may be quite high.

While knowing plant water status is useful, it doesn't tell you how much water is left in the reservoir. So you cannot predict when you need to put more water on.

Kicking the dirt

Soil based measurements can indicate how hard the plant has to work to access water, and how much water is left in the tank. Digging holes and feeling the soil can give guidance, but proper tools do a much better job.

The first technology to be in common use was the tensiometer. A tensiometer is a tube filled with water, with a porous cup at the base and a vacuum gauge at the top. Water can move through the porous cup. As the soil dries, it pulls water from the tube, creating a vacuum that is measured by the gauge.

Tensiometers measure soil matric potential – how tightly the water is held by the soil. This is important, as it is the best indication of plant stress and growth. Once about half the available soil water is used, the tension increases rapidly and the plant has to work a lot harder to take up water. Growth rate is reduced. When the plant cannot get any more, growth stops.

Other equipment can measure how much water is in the soil. A volumetric measurement is useful because it shows how many millimetres of water are left in the root zone.

Neutron probes release fast neutrons into the soil. Hydrogen atoms intercept the neutrons, slowing them down. The probe counts the slow neutrons returning which shows how many hydrogen atoms are present. Water is the only hydrogen atom supply that changes in the short to medium term, so the probe count measures soil moisture status.

A neutron probe measuring soil moisture in a Radiata pine breeding nursery

Other moisture meters rely on the 'soil dielectric', a property that changes in response the soil moisture levels. The two main systems are time domain reflectance and frequency domain reflectance.

Time domain reflectometers (TDR's to most of us) measure the time for an electrical impulse to travel down metal probes and return to the meter. The speed is affected by soil moisture. Because probe length is known, measuring reflectance time allows moisture status to be calculated. You need multiple TDR's to measure moisture at different depths through the profile.

Frequency domain equipment utilises properties of an electric field that is associated with paired electrodes in the sensor. The electric field extends from the electrodes out into the soil, and again is affected by changing soil moisture. So it too, can be used to calculate how much water remains. Most systems measure soil moisture at several depths in the soil at once.

While knowing how much water is left is useful, it doesn't tell you how fast you are using it.

Having a guess

Just as with finance (and petrol tanks), it's much better to run a budget! A soil water budget tracks deposits and withdrawals, and lets you ensure you stay with your limits.

You need to know what the maximum and minimum levels are to know your credit limits. You want to know your available, and readily available, water capacities.

A water meter tracks irrigation use accurately

Deposits are mainly rain and irrigation. A rain gauge and water meter let you track and record these accurately. Withdrawals include evaporation from the soil and transpiration by the crop. These are a bit harder to measure, so we often make estimates.

The amount of water evaporated and transpired by healthy well watered grass covering 100% of ground area is known as potential evapo-transpiration or PET. PET is published regularly in most districts, based on weather station measurements at research stations.

If you don't have access to this figure you can use an evaporation pan. (Crudely speaking, chop the bottom 300mm off a 200L drum and paint it silver. Sit it out in the crop, half full of water, and measure how much gets lost each day. Cover it to keep pets out.)

An evaporation pan loses more water than grass does, so you need to reduce pan depth lost by 20%. For example: If your pan loses 5mm of depth in one day, this is equivalent to 4mm PET; 5mm x 80% = 4mm.

You still need to adjust the PET for your crop (which is not grass and doesn't cover all the ground). A good rule of thumb comes from the amount of ground shaded at midday. If the crop canopy shades only 75% of the ground at lunch time, PET is reduced accordingly. Bare soil will lose some moisture – usually at about half the rate of the crop. (Note: Irrigated grass in orchards can use water at PET rate.)

To carry the example on: For the crop, 4mm PET x 75% = 3mm Crop ET. For bare soil, 4mm x 25% x ½ = 0.5mm. So your soil moisture account has reduced by 3 + 0.5 = 3.5mm.

A soil moisture budget brings together plant water use, water additions, and the size of the reservoir. It records what you have used, and predicts when more will be required.

A soil moisture budget using measured or estimated plant water use data, supported by good soil moisture monitoring, is the belt and braces you need to ensure your management is effective.

Let's use them together.

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