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ALMOND BOARD OF AUSTRALIA

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QUICK GUIDE FOR USING SOIL WATER EXTRACTION DEVICES

Introduction

Soil Water Extractors (SWE), also known as Suction Lysimeters, offer a quick and easy method for irrigators to check the chemistry of the soil water in their rootzone. There are several commercial providers of SWE's and those described in this guide reflect the practicality and function of the different models available. This guide has been developed for a SWE designed in the Sunraysia region of Victoria, Australia (Figure 1).

SWEs are quick to install, easy to use, and allow for immediate field testing of soil water chemistry (e.g. nutrient and chloride salts). These field samples offer immediate and cheap information to quickly inform irrigation and nutrient management decisions. SWE samples can also be validated by laboratory testing if required. This factsheet provides an overview of how SWE's work and general instructions for installation, sample collection and analysis.

What is an SWE device and why would you use one?

An SWE is a device which helps extract a water sample from targeted soil depths that can then be assessed for the concentration of dissolved nutrients or chloride salts. SWEs can be positioned at multiple depths in the rootzone to monitor the movement of nutrient through the soil profile. This information can help inform decisions around the timing of salt leaching events or the management of nutrient applications.

How do SWEs work?

SWEs operate under negative pressure which is created using a vacuum pump to mimic soil water pressures applied by the irrigator. The negative pressure draws in soil water through a hydrophilic ceramic tip. The ceramic tip mimics the plants roots by absorbing the water from the spaces between the soil particles. If the ceramic tip is dry, or if there is no water in the soil profile, the SWE can't extract a water sample.

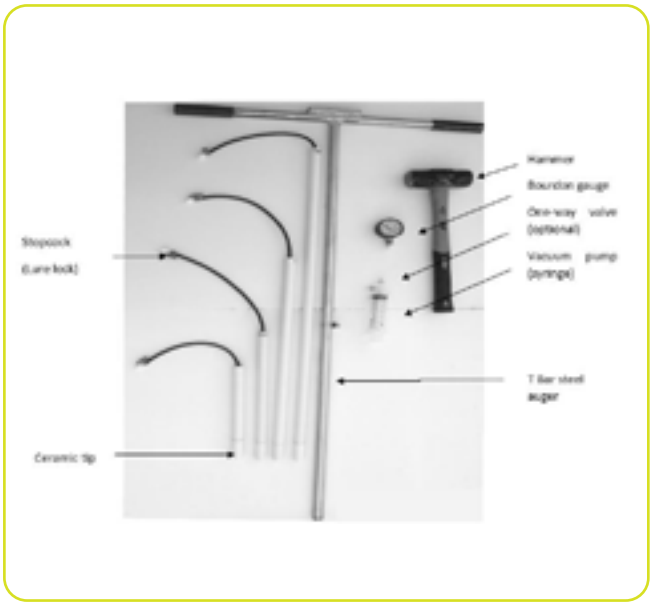

Figure 1: Component parts of the soil water extraction (SWE) device also known as a Suction Lysimeter.

Figure 2: SWEs installed in a cluster or nest at three depths 30cm, 60cm and 90cm can monitor the movement of soil water and nutrients into the soil profile.

Equipment you will need

Required components:

- 20mm diameter T handle steel auger. See below for instructions to make your own auger.
- 4.5kg or 12kg sledgehammer.
- SWE tubes for the depths required#.
- 60ml or 50ml syringe#.
- Test strips* with colour chart for specified nutrient concentration.
- One-way valves^ and Bourdon gauge# (gauge is optional to show when the soil water is at a similar pressure as it takes for tree roots to access soil water).
- Bucket.
- 1-2L of water for each SWE.

The one-way valve allows multiple priming pumps without having to disconnect the syringe from the SWE to recharge. But if one-way valve is not available, you will need to trap the vacuum within the SWE by closing the stopcock before pushing the air out of the syringe and then reopening the stopcock to create pressure by drawing on the syringe. This opening and closing of the stopcock will need to be done multiple times in between each draw on the syringe.

* Test strip suppliers: can be purchased online or from local agriculture suppliers.

Additional supplies: Kovac Electronics bob@kovacelectronics.com.au

^ The vacuum pump (syringe) can be operated with and without the one-way valve (shown in Figure 1 and 4).

How many SWEs are needed?

Ideally, SWEs should be installed in a nest or cluster of three at depths 30cm, 60cm, 90cm (Figure 2). The deepest one should provide an indication of moisture and soil water chemistry at the bottom of the rootzone, while the shallow depth will give an indication of available nutrients in the soil surface. The 60cm depth helps to track movement between the surface and deeper rootzone.

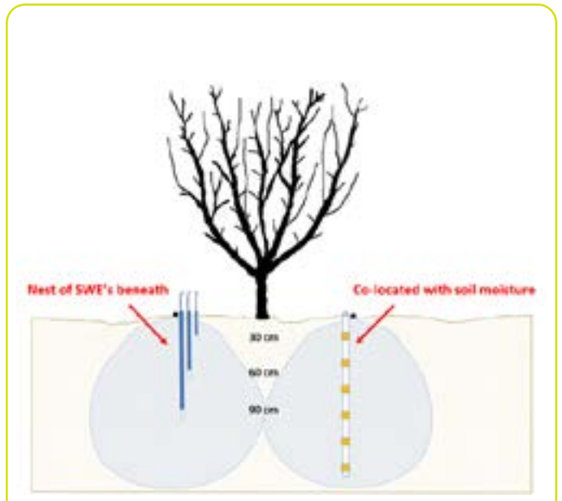

Figure 3: A schematic of SWEs installed at three depths 30cm, 60cm and 90cm in the tree row near a drip emitter.

Figure 4: Close-up of syringe attached to the SWE. The stopcock is 'open' ready to prime the SWE. After priming the blue tap would need to be closed before disconnecting the syringe. The syringe and tube is now primed i.e. at a negative or suction pressure needed to draw water from the soil profile.

Where should SWEs be installed?

Some properties may have more than one soil type across the orchard and clusters of SWEs at multiple locations may be needed to better understand the rate of nutrient and salt movement through different soil textures. For example, water and dissolved salts move relatively quickly through sand and more slowly through clay. Data collected from different locations would assist in characterising the variability across an orchard and identify areas where there may be an inefficient application of fertilisers or salinity hotspots.

SWEs are best installed within the wetting pattern of a sprinkler or drip emitter, approximately 50cm to 70cm from the tree base, and at multiple depths (Figure 3).

Co-locating SWEs near soil moisture probes (if used) would assist in cross-checking and interpreting trends in nutrient and salt movement as measured by SWE (refer trouble shooting).

How to make a 'T' handle - steel auger

To make a 'T' handle for your steel auger cut two lengths of 20mm diameter solid steel rod, one at 40cm and the other 100cm. Round off the bottom of the 100cm length with a grinder or lathe. Weld the longer length of rod to the middle of the shorter length at 900 to create a 'T' handle (Figure 5). Some SWE models require larger holes but similar installation method (follow SWE manufacturer instructions).

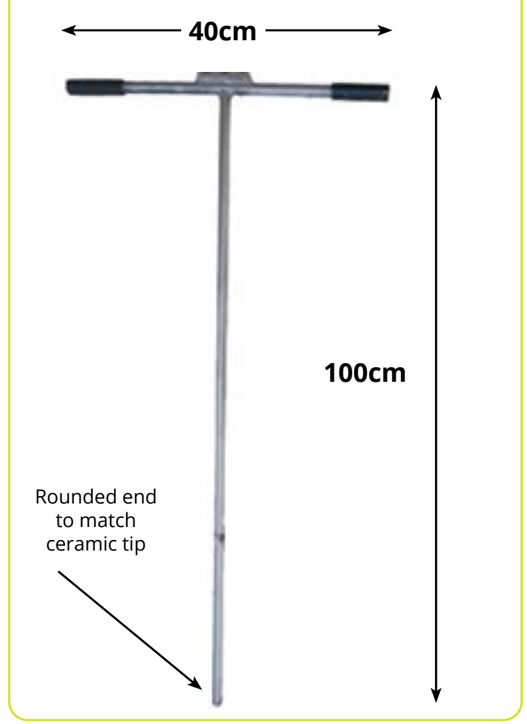

Figure 5: T-bar steel auger dimensions.

Installation instructions

Select a location around 50 to 70cm away from the tree base in line with the dripper line or in the sprinkler spray pattern. Make sure the distance between nested SWEs is approximately 40 to 50cm.

1. Pre-soak the ceramic tip in a bucket of water.
2. Pre–measure and mark the auger at the desired depth e.g. 30cm with tape.
3. Place the auger in position and drive it into the ground with a sledgehammer. If the soil is heavy rotate the T bar slightly between hits. This will make it easier to withdraw the auger after you have driven it to the required depth. Keep the auger upright to ensure the hole has straight sides and provides a 'snug' fit with maximum soil: tube contact.
4. When the desired depth is reached remove any soil around the base of the auger and gently remove the rod without disturbing the soil. Note that the installation rod may be difficult to remove from heavy clay soils. Mechanical removal may be required.
5. Moisten the hole by adding around 30ml of water being careful not to wash surface soil into the hole.
6. Slowly insert the pre-soaked ceramic tube in the hole to the desired depth. Keep the tube vertical at all times. Note: DO NOT twist the tube.
7. Backfill any gaps around the top of the tube to prevent the ceramic tube from moving and any surface water funneling into the hole. Water in the soil around the top of the tube to ensure good surface seal.

8. Attach the syringe to the stopcock on the end of the polyethylene tube. Turn the stopcock to the 'open' position. Pump the syringe 'in' and 'out' two to three times (like a bike pump) to create the required vacuum.
9. When the desired vacuum is reached turn the stopcock to the 'closed' position.
10. Remove the syringe from the tube and attach the plastic cap.

Checking the vacuum

Check the vacuum in the tube immediately after installation to make sure the SWE is working as it should and at the right vacuum (refer to the ideal vacuum below).

Attach the gauge to the outlet on the syringe, open the stopcock and the guage should show the current vaccum. Wait for approximatly 20 seconds to make sure the vacuum is stable and not decreasing. If the pressure is stable – turn the stopcock off and remove the vacuum gauge.

If the vacuum decreases the ceramic tip may be damaged. Remove the tube carefully by pulling it out without twisting. Check for damage by placing the ceramic tip in a bucket of water and apply a positive pressure using the syringe and gently push air through the ceramic tube. If large air bubbles appear in the bucket of water there is a leak and the SWE should be replaced.

Achieving the ideal vacuum

For all SWE depths the ideal vacuum is between -40 to -50 kPa as this resembles the suction pressure used by plant roots to extract moisture from the soil (Figure 6). In light sandy soils two pulls of the syringe should be enough to achieve the required vacuum. In clays more effort is required to extract the water and the syringe may need three pulls to achieve the required vacuum.

Figure 6: The gauge shows the ideal vacuum for the SWE (-50 to -60 kPa). Heavier soils may need priming to -70kPa in order to extract soil water.

How to collect a soil water sample

Sampling instructions:

Before you start, make sure you have all the required equipment at hand including syringe; sample bottle; test strips and container; record sheets and pencil; water and a cleaning cloth.

1. Remove plastic cap and place cap on a clean cloth and not on the dirt.
2. Open the stopcock. A gentle 'hiss' may (but not necessarily) be heard as the air enters the tube.
3. Carefully attach the syringe to the stopcock on the end of the polyethylene tube.
4. Hold the syringe horizontally (level to the ground) and slowly draw the syringe back.
5. Water will enter the syringe. Close the stopcock and remove the syringe and pour the sample into bottle.
6. Take a paper strip from the test kit and add 3 to 4 drops of the sample on the test strip.

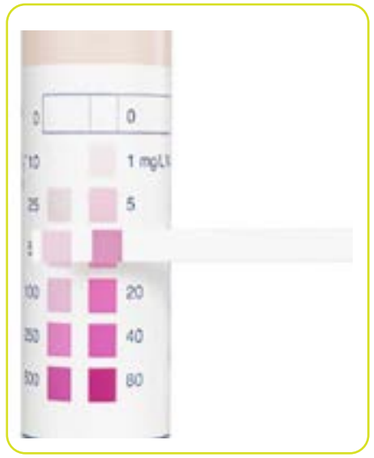

Figure 7: The test strip colour indicates the concentration of dissolved nutrients in the soil water sample.

7. Wait for 2 to 3 minutes until the test strip changes color.
8. Compare the strip with the color chart on the container to determine the concentration of dissolved nutrients (Figure 7).
9. Record the concentration on the record sheet.

The volume of water extracted is determined by the soil moisture. If the soil is wet or saturated, the sample may be up to 30ml or more. If the soil is dry, there may only be a few drops or nothing at all.

Prime the syringe after sampling

Priming the SWE after taking each sample and leaving it primed between readings will make it easier to collect future samples. Priming creates a negative or suction pressure needed to draw water from the soil profile.

10. Open the stopcock.
11. Using the syringe vacuum valve assembly connect to the stopcock and pump several times to create a vacuum (refer ideal vacuum)
12. Close the stopcock, remove the syringe and replace the plastic cap.

If the SWE isn't primed after each reading it will need to be reprimed the day before taking the next sample. Remember the soil water sample is representative of the soil water at the time the SWE is primed.

When is the best time to collect a sample?

Samples can be taken anytime following an irrigation or rain event, allowing enough time (12-24 hours) for water and nutrients to move down through the soil profile. It is important to note, samples reflect the soil water status at the time of priming, even though there may be a delay in time (e.g. one week) before the sample is collected.

How often should samples be taken?

Ideally samples would be collected as frequently as practical during the period of fertigation (up to weekly) and then less frequently outside of the fertigation period (every two to four weeks).

Alternatively, sampling may target a critical growth stage to improve decision making. In this instance set up the SWE at least two weeks before sampling and prime the device 24 to 48 hours before fertigation. Collect the samples approximately four days after fertigation.

Once you know how the soils respond sampling frequency may be scaled back to once a year as a cross-check to make sure things are as expected.

- High frequency sampling – as often as weekly (but more likely fortnightly) during the fertigation period for greater precision on nutrient movement from one depth to the next.
- Moderate frequency sampling – monthly only through the fertigation period to get better insight into nutrient trends.
- Low frequency sampling – once, within the first month of the fertigation period to confirm nutrients are reaching the desired depth.

The frequency of sampling is likely to change as you get a better understanding of how the soil is responding to the fertigation schedule. When starting to use SWEs a High to Moderately frequency provides greater value. Lower frequency sampling can be adopted once the behavior of the soil is better understood provides a cross-check each season.

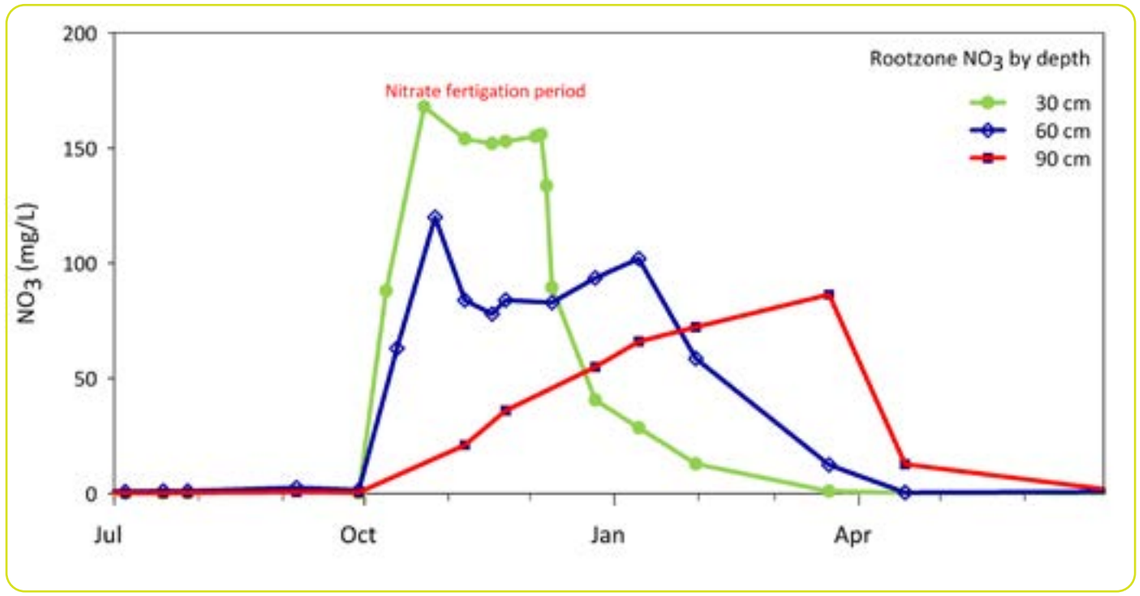

Figure 8: Example of nutrient data collected using SWEs which can be graphed to show changes over time.

Interpreting the data - what to expect

Soil water samples will indicate the presence or absence of soil water and enable measurement of nutrient concentrations at chosen depths. Over time changes in concentration of nutrients at each depth will show the movement of water and nutrients through the soil profile (Figure 8).

The rate of water and nutrient movement through the soil is dependent on the soil type. Soils with higher clay content have smaller particles and slower water movement. Whereas sandy soils have much larger spaces between particles allowing water to move through the soil more freely.

Troubleshooting

What does it mean if no water can be extracted?

- SWEs installed at depth e.g. 90cm may extract less water because this is located at the bottom of the rootzone where there is less water available in the soil. Note that high volumes at this depth could indicate water moving beyond the rootzone.
- Soil may be dry, and no free water is available to extract from the soil. This may occur when roots are actively growing and taking up all the soil moisture available. Check the nearby capacitance probe (if available) to see if there is water at the relevant depth. If the capacitance probe is showing there is no water at the same depth, then no action is required. If there should be water and the SWE isn't picking it up, then remediation is required.
- The ceramic tip may have dried out between irrigations. To create a positive pressure and re-establish connection with the soil water fill the syringe with about 30ml of water and gently drive water through the ceramic tube.
- There may be small clay particles (heavy soils) on the surface of the ceramic tip preventing water uptake. Fill the syringe with about 30ml of water and carefully push the water through the syringe to apply a positive pressure through the ceramic tip to dislodge the silt.
- If calcification is suspected, use a 30ml solution of 50% white vinegar and 50% water to create a positive pressure and push through the ceramic tip to dissolve the calcium. Note this will have a short-term affect the pH readings of the soil water extracted after cleaning the tip.
- If water is unable to be extracted for two or more readings, and the steps above have not been successful, then replace the SWE.

What to do if you hit a root?

- You will know if you hit a root when the steel rod can't penetrate the soil. If this is the case remove the T handled auger and create a new hole close to the original site but far enough away to avoid hitting the root again. Do this until the desired depth is reached.

What to do if soil falls back into the hole?

- If soil drops into the hole after the auger is removed reinsert the auger to the correct depth, clean area at the soil surface to prevent more soil dropping into the hole and keep the auger upright when removing it to prevent disturbing the surrounding soil.

What to do if you forget to wet up the hole?

- If the tube has been installed without wetting up the hole first. Open the stopcock and inject 30ml of water into the tube with the syringe. Close the stopcock and leave it for half an hour before drawing out any remaining solution, and then re-prime the tube.

What to do if you forget to wet-up the ceramic cap?

- Do exactly as if you forgot to wet up the hole.

Does using water during installation affect the first reading?

- The process of wetting up ceramic tips and applying positive pressures to clean off built up silt can dilute the first nutrient reading. This should stabilise after the next fertigation.

Can I test for other nutrients in the water sample?

- Yes. Water samples can be sent to a laboratory for analysis of other ions similar to analysing leaf tissue or soil samples. Test strip papers are available for multiple nutrients e.g. Nitrate, Phosphate, Potassium and others. Brands include Precision laboratories and Quantofix which can be purchased online or local agriculture suppliers.
- Handheld Electrical conductivity (EC) meters, such as those made by Horiba, can test for multiple nutrients and can also indicate the presence of nutrient salts (and/or characterise salinity trends). Note that EC meters also respond to nutrient salts, so salinity readings are best collected outside the fertigation period.

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