Information Sheet

5.17 Placement of soil water sensors for irrigation scheduling

Introduction

Water is a finite resource and the competition for water from other sectors is increasing. To use this scarce resource optimally, we must manage all aspects of irrigation to minimise water loss and maximise production. **Irrigation scheduling** is an important practice that aims to apply the **right amount of water** required by the crop, at the **right time** and to **avoid losses** due to run-off and drainage. Soil water sensors have become a common way to schedule irrigation. Tensiometers, gypsum blocks, wetting front detectors, neutron probes, capacitance and resistivity probes, and time domain reflectometry instruments are a few examples of sensors and technologies supplied by numerous manufacturers. More information about soil water sensors can be found in Information Sheet 5.4: Irrigation Scheduling Toolbox. However, despite their usefulness, these sensors, will not provide the advanced scheduling benefit possible if they are incorrectly used or placed in the soil. This information sheet provides guidelines and recommendations on the placement of soil water sensors.

How many soil-water measuring stations to install per field?

A measuring station can consist of single or multiple soil water sensors. A single measuring station typically includes equipment that can measure soil water status at multiple soil depths (e.g. capacitance probes). Other sensors (e.g. gypsum blocks, tensiometers, or resistivity sensors) can only measure soil water at one depth, and therefore require two or more sensors to make up a measuring station. A measuring station, therefore, provides data for a single point location, independent of the number of sensors installed, and is used as a reference for managing larger areas. Selecting the number of stations to use and appropriate placement is thus of critical importance. The criteria for selecting the number of measuring stations can include uniformity (or variability) of the soil, size of the total area to be scheduled, irrigation infrastructure (i.e. block layout/control area), cost of instruments, total time to read all sensors, maintenance of sensors, diversity of crops and crops with a similar age. There are therefore no definitive rules to guide the number of stations to be installed. The following can be used as a general guideline:

Uniform soils:

- In fields where soils are uniform in soil colour, depth and texture (clay %), **one monitoring station per irrigation control area (irrigation block) will be adequate**, provided that the control area contains crops of a similar age.
- In larger irrigation blocks/fields with uniform soil, changes in slope or topography may require additional measuring stations.
- The area represented by a measuring station should ideally not exceed 30 ha.

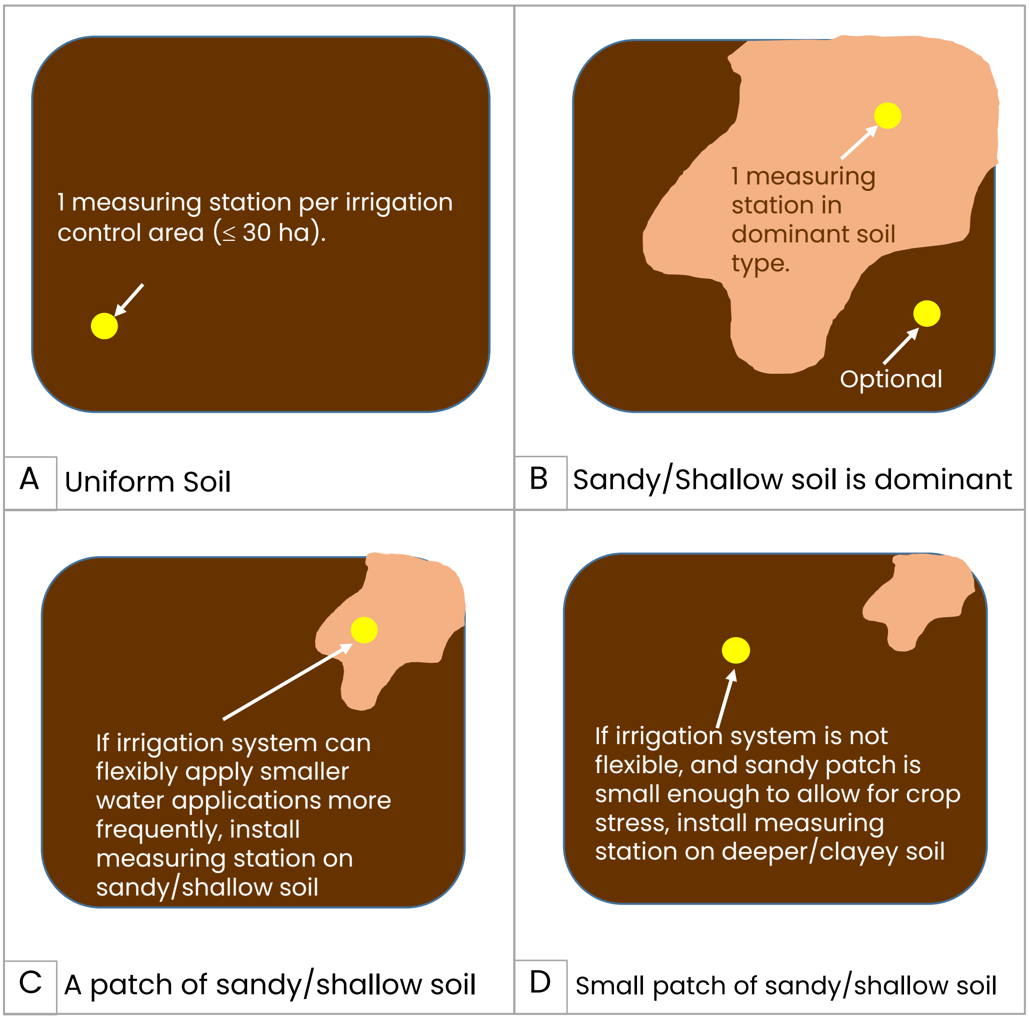
Non-uniform soils:

- As soil variability increases, the number of measuring stations should also increase (within reason). Homogenous (similar) management zones should be defined within a field or irrigation block, according to grouping of soil colour, depth, texture (clay content), slope or a combination thereof. Ideally, each zone should be equipped with a measuring station. This is, however, often not practical. Generally, irrigation infrastructure is set up to apply water uniformly over the entire block, hence only one measuring station should be used for scheduling a field or irrigation block. The following are guidelines for the placement of measuring stations and the associated irrigation scheduling in fields with variable soils.

i. Areas with the sandier (or shallower) soil will have a lower water storage capacity and thus need more frequent irrigation compared to the areas with more clay (or deeper soil). We recommend installing the measuring station in the sandier (or shallower) soil and bringing the whole field (all the soils in the field) to field capacity (this will result in an initial over-irrigation on shallow/sandy soils). Thereafter irrigation should be scheduled for the entire block according to the soil water sensors installed in the shallow/sandy soils. The water levels in the deeper/clayey soil should be periodically assessed using augers or soil pits and extra irrigation applied if required.

ii. If the sandier (or shallower) area is relatively small, then the block should still be irrigated according to the weaker area. However, if the grower is prepared to allow this small area to stress between irrigations, then the irrigation requirement of the area with a higher water holding capacity (higher clay content or deeper soil) should be followed.

The figure below summarises the above guidelines.



▲ Figure 1: Guidelines for the placement of measuring stations: A) Soil of the total block is uniform, B) Two distinctly different soils are present with the weaker sandy (or shallow) soil dominant, C) Two distinctly different soils are present with the weaker sandy (or shallow) soil not dominant but still contribute significantly to the overall yield of the field, and D) Two distinctly different soils are present with the weaker sandy (or shallow) soil not dominant and its yield contribution is insignificant to the overall yield of the field.

In addition, the following must be considered when positioning the measuring station:

1. Avoid low lying areas with wet spots or poor drainage, steeper terrain and other anomalous or unusual features, which are not likely to be representative of the wider area.

2. Functional requirements to collect the data (e.g. distance and line of sight for radio signals, or cellular or Wi-Fi signal for internet connectivity).

3. Do not install sensors close to metal objects (i.e. irrigation equipment, overhead power cables and fences) and water carrying infrastructure (i.e. metal or PVC buried or surface pipes).

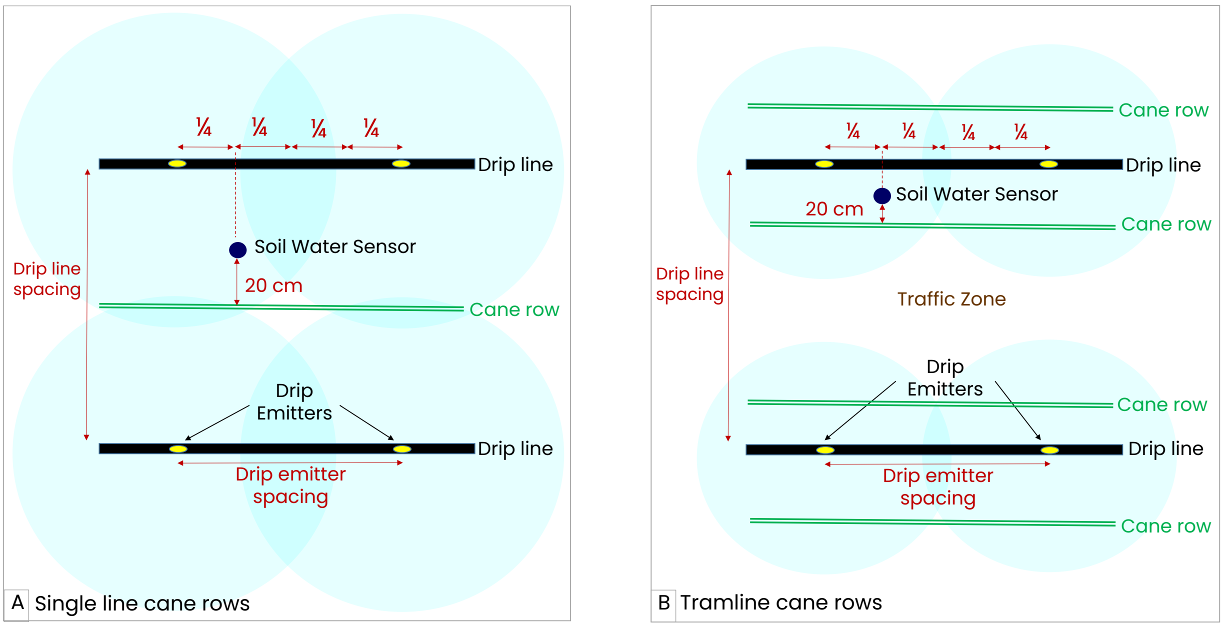
4. Positioning, marking and protection from infield operations (weeding, burning, harvesting and loading) and traffic (stay clear of animal paths, tractor paths, centre pivot wheel tracks and infield extraction routes).

5. Proximity to roads or cane breaks for accessibility (access requirements for manual downloading of data or for repairs, replacement of batteries, etc.).

Where to place sensors relative to the cane row and infield irrigation equipment?

Sensors are used to indicate the amount of water present in the soil. If data is recorded at regular intervals, then the rate of water extraction by the crop can be calculated. Water is depleted fastest from the area with the highest concentration of roots. The rate of water extraction reduces the further you move from this zone. However, the soil at some distance from the high concentration of roots does contain water that can be utilised by the plant. Plants might initially not show signs of stress as the crop starts to rely more on the soil away from the high-density rooting zone for water. However, some level of water stress materialises on hot and windy days, especially in mature crops. Thus, to enable water-use from a larger soil volume, placement of the sensor is important. To achieve the above, **the sensors should be placed about 20 cm from the edge of the stool in the interrow** for all irrigation systems (centre pivot, drip and sprinkler systems). In controlled traffic systems with dual cane rows, sensors should be placed in between the narrowly spaced cane rows and not in the interrow (traffic zone).

In fields irrigated with dripper systems, sensors must be installed so that the cane row is not between the dripper line and the sensor. Also, if the sensor is placed directly below the drip emitter, it will reflect wetter readings and result in longer irrigation intervals. As illustrated in Figure 2, we recommend installing the sensors a quarter of the distance away from the drip emitter and 20 cm away from the cane row for single line and tramline cane row configurations. The circular blue shaded areas reflect an aerial view of the typical wetting pattern for drip emitters in Figure 2 and for overhead sprinklers in Figure 3.



▲ Figure 2: Recommended placement of soil water sensors in drip irrigation systems for: A) Single line cane rows and B) Tramline cane rows.

In fields irrigated with overhead systems, sensors must be placed a quarter of the distance between sprinkler risers and a third of the distance between irrigation lateral lines. This does not apply to pivot systems, but the rule of placing sensors 20 cm from the cane row must be followed.

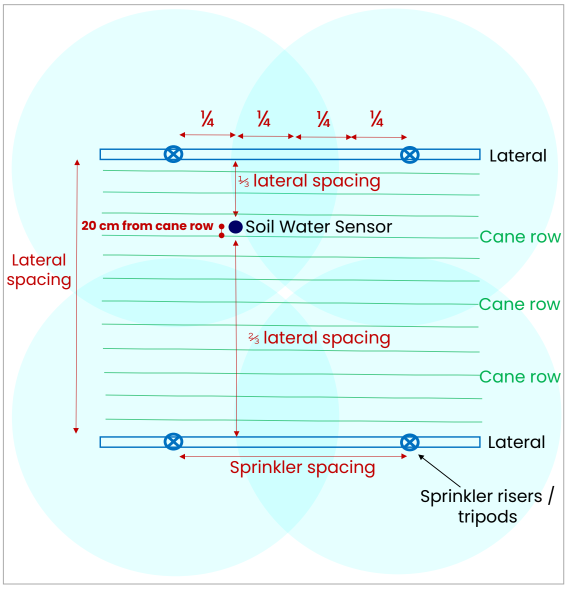


Figure 3: Recommended placement of soil water sensors in sprinkler irrigation systems.

How deep to measure down the soil profile?

In irrigated crops, a large portion of the root biomass is found closer to the soil surface and decreases exponentially with soil depth. Approximately, 50 - 60% of the total root system is found in the top 200 mm of soil. When there are no soil limitations or restrictive layers (e.g. compacted layer or shallow water tables), the effective rooting depth (depth in which 80% to 85% of the total roots occur) of irrigated sugarcane is between 400 and 600 mm deep.

The most important depth to monitor soil water content is 0 - 20 cm. Thereafter, it depends on the measuring system used, the availability of sensors and the cost per sensor. Capacitance probes, for example, detect soil water status at 10 cm intervals, usually up to a depth of 60 or 80 cm. If using a sensor that measures at one depth only, a measurement station can be set up with two or three sensors. A two-sensor station can be installed at 20 and 50 cm depth, while a three-sensor station can be at 20, 40 and 60 cm. Covering depths greater than 60 cm is less important, unless there is specific intent to make better use of the soil's water storage capacity, or to monitor for shallow water tables.

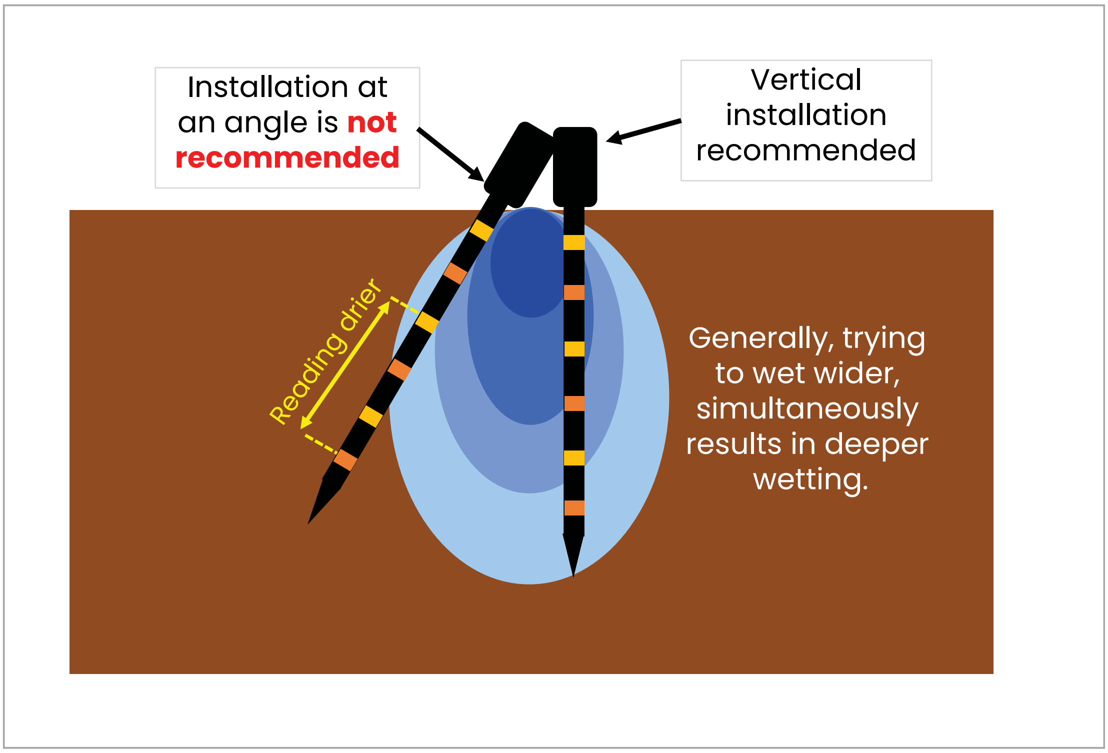
Correct sensor installation

Sensor installation is a critical activity and should be done in accordance with the manufacture's guideline/manual. When uncertain, ask an Extension Specialist or consultant to assist. The sphere of soil measured by most soil water sensors is only 1 to 5 cm. It is therefore critically important to install them with no cavities and to ensure good contact between the soil and the sensor. It is also very important to prevent preferential water flow along the vertical surface of the sensor in the disturbed soil. To achieve this, the installation hole should be just big enough to install the sensor or access tube. A good practice is to make a slurry, using soil augured from the hole. The soil-water slurry is poured into the hole to cover the gap between tube or sensor and the soil. In addition, the soil at the surface should be raised slightly above the natural ground level around the access tube and sensor cable. This will settle in time, but along with the slurry will go a long way to prevent preferential flow and air pockets. After installation, the sensor readings should reflect the wetness of the slurry and subsequent change as the slurry dries out. Something is wrong if this does not happen.

Some of the short sensors (less than about 20 cm) can be installed horizontally to prevent the risk of preferential water flow. To do this, a pit is normally opened near the desired location and the sensors are carefully pushed into the side of the pit at the predetermined depth. If the soil is too hard, a metal object with the same dimensions as the sensor can be forced into the soil and withdrawn, before the sensor is pushed into the soil. After installation, the cables should be secured, and the pit closed.

Sensor orientation: vertical, at an angle or horizontal?

The sensitivity to orientation of soil water sensors is greatest under drip irrigation and for longer instruments, such as the capacitance probes, which simultaneously measure soil water at multiple depths. This is because drip emitters wet the soil from a point source and distributes water in the soil in the shape of an onion bulb, i.e. depth and width of wetting zone are not always equal. The wetting pattern is dependent on soil texture and emitter flow rate, but generally, achieving wider horizontal distribution also results in deeper wetting. As shown in Figure 4, installing the probe at an angle can lead to drier readings from sensors at the bottom of the instrument, which can incorrectly trigger irrigation when there is still sufficient water at depth. For this reason, SASRI recommends vertical installation of capacitance probes.



▲ Figure 4: Recommended orientation of capacitance probes under drip irrigation.

Instruments such as the neutron probe and certain time-domain reflectometry (TDR) models can be moved between several access tubes and is designed to lower the sensors down an access tube and is therefore best installed vertically.

Dielectric type sensors and conductivity blocks (gypsum blocks) are much shorter (up to about 20 cm) and are, therefore, less sensitive to orientation. The user has an option to install them either vertically or horizontally. Vertical installation, however, allows for easier reclamation with less damage if sensors are to be relocated.

Guidelines and recommendations for the placement of soil water sensors for irrigation scheduling have been presented in this information sheet. The placement of soil water sensors is typically dependent on the uniformity or variability of soils, type of irrigation systems and the nature and cost of the sensors. If there is uncertainty regarding optimal sensor placement, please consult with the SASRI Extension Specialists or irrigation advisor.

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October 2021