FACTSHEET
Managing salinity

How to determine the salinity of the soil/substrate through electrical conductivity measurements

Action points

- ✓ Determine the sensitivity of the crop to the salinity of the soil/substrate
- ✓ In the case of soil-grown crops, analyse the soil for salinity
- ✓ Decide if it is necessary to constantly monitor the salinity, and with what frequency
- ✓ Consider the cost as a factor for choosing the technology to be used

INTRODUCTION

The salinity of the soil/substrate can have a negative effect on crop growth and production. Therefore, it is important to assess salinity in order to recommend irrigation management that minimises these negative effects on the crop. Salinity can be evaluated by measuring the electrical conductivity at 25ºC (**EC_{25}**). The main methods accessible to farmers, technicians and agricultural consultants are presented here.

How it works

The electrical conductivity (EC) of a medium is the capacity of the medium to conduct an electrical current. In an agricultural soil, that medium can be a **soil sample**, the **soil solution** or the **soil *in-situ*.** In the first and second options, EC can be measured with a conductivity meter. In soilless crops, a conductivity meter can also be used to measure the EC of drainage samples.

The EC is directly proportional to the salinity; by measuring EC we can estimate salinity. However, EC measurement is also sensitive to temperature. Consequently, the EC and temperature of the sample should be measured simultaneously, and then measured EC value is standardised to the reference temperature of 25ºC. The standardised measurement is known as EC_{25}. Where combined direct measurements are required of the moisture content, EC and temperature, either in soil or substrate, combined sensors that measure the three parameters can be used.

EC in saturated soil extract

For this method, a soil sample is taken in the field and sent to a laboratory. Trained technicians saturate the soil sample and apply suction to draw out the saturated solution, known as the 'saturated extract,' in which EC is measured (**EC_{se}**). Practical limitations of this method include the results not immediately being available, and the large amount of soil required from numerous soil samples. High soil gypsum content can interfere with results. Alternative methods are soil solution methods and direct measurement in soil.

EC in the soil solution

The most common way to measure EC in the soil solution is by using ceramic cup **soil solution suction samplers** (available from 80 €). The ceramic cup is installed at the desired sampling depth in the soil. A vacuum (-60 kPa) is applied to each sampler using hand-held pumps. To establish a negative pressure gradient from the soil to the cup, it is most effective to do this when the soil is at or close to field moisture capacity (i.e. shortly after irrigation or rain).

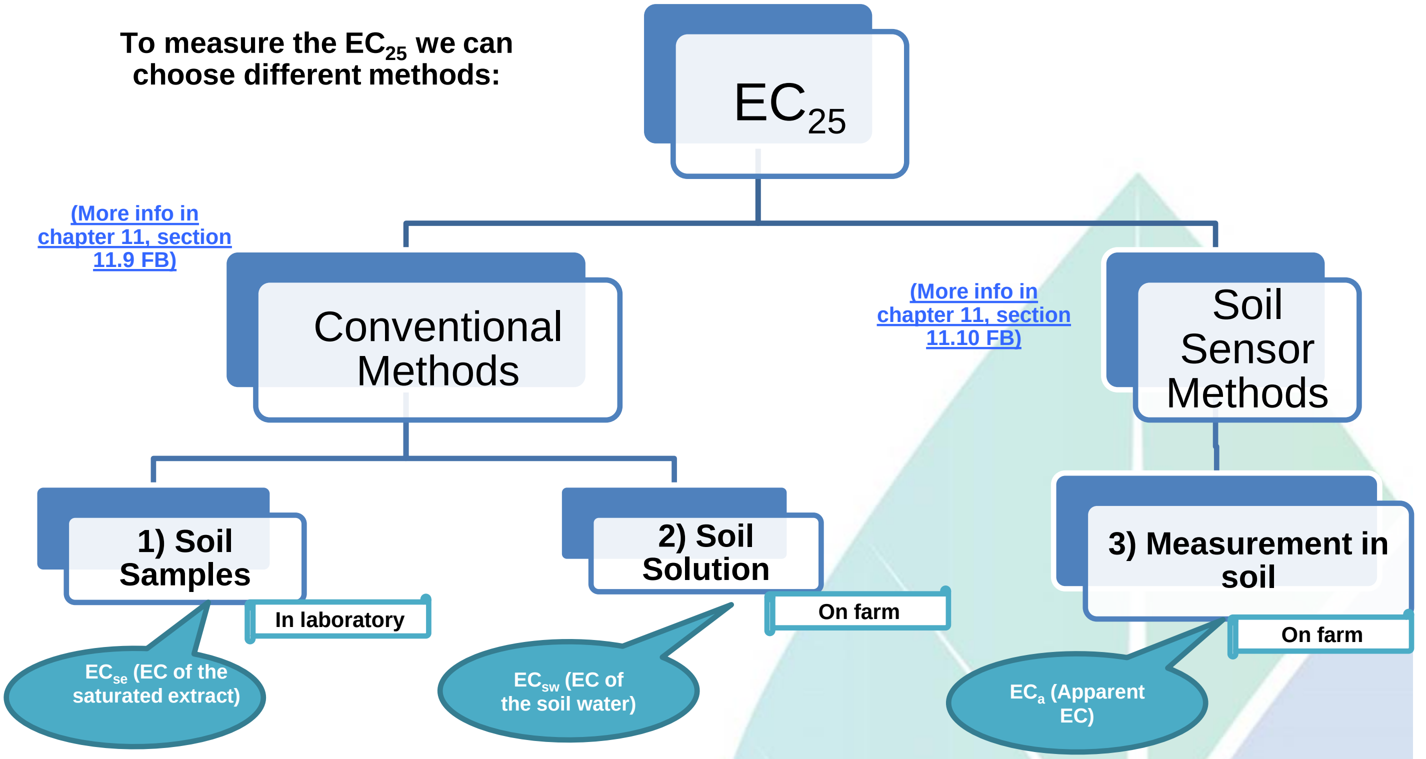
With a hand-held EC meter, the EC of the soil solution or soil water (**EC_{sw}**) is measured. This EC_{sw} is representative of the water taken by the plant's roots. Using soil solution gives a better representa-tion of the level of salinity, compared to the saturated extract. However, the use of ceramic cups is relatively new, and EC reference values are not commonly available. An important practical limitation is that they require moist soil.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689687

FERTINNOWA

FACTSHEET
Managing salinity

To measure the EC_{25} we can choose different methods:



Normally 2) and 3) require several permanent sampling devices, which disrupt the soil's initial state. Because of this, it is advisable to wait for a few months after installation before data can be accepted as reliable.

Recent alternative methods are the **wetting front detectors** or Full-Stop, which don't require the application of a vacuum. As with suction samplers, they can be installed at different depths. A permanent conductivity meter can be installed inside the sampler.

EC_{se} (EC of a saturated extract) can be estimated using EC_{sw}. This is then compared with established EC_{se} reference values to assess the salinity risk.

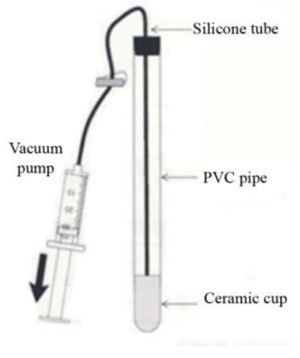


Diagram of a soil solution suction sampler

Direct EC measurement in the soil

Apparent EC (**EC_a)** is measured directly in the soil with a sensor. Measurement of EC_a is affected by soil texture and soil moisture. EC_{sw} can be estimated from EC_a, and EC_{se} subsequently estimated from EC_{sw}. EC_a measurements can be made with different sensors. Some can be used to map fields and to characterise spatial variation.

Electrical resistivity (ER)

ER measurements are based on the inverse relation-ship between EC and the resistivity of a material (resistance of a material to the flow of an electrical current). As resistivity goes up, EC goes down, and vice versa. By measuring the electrical resistivity of a known volume of soil or water, the EC_a can then be found.

This type of sensors demand good sensor-soil contact. Prices are provided in the Fertigation Bible.

Reflectometry

Relectometry measures the effect the soil has on alternating electric currents, which are read by electrodes fixed in the soil. The main purpose is to measure soil water content, but it can also be used for measuring EC. There are three types of reflectometry sensors: 1) Time domain reflectometry (TDR), 2) Amplitude domain reflectometry, and 3) Frequency domain reflectometry (FDR). A wide range of products varying in price and performance are available (for further information, see table 11-7 FB, reference 1).

Reflectometry sensor used to take measurements on rockwool substrate (https://www.delta-t.co.uk)

Electromagnetic induction (EMI)

A transmitter coil located at one end of the instrument applies a magnetic field to the soil. This generates a secondary electromagnetic field in the soil which is then detected by a receiver coil loca-ted in the instrument. This signal is related to the EC_a (when EC_a increases, so does the signal). This type of sensor does not need device-soil contact. They are fast, but expensive.

Some of these sensors can also be used in some substrates used in soilless cropping.

Electromagnetic sensor (http://agrosal.ivia.es/evaluar.html)

EC measurement of substrate drainage

Samples of substrate drainage can be easily collected. EC can be measured either manually or automatically using a hand-held conductivity meter. These measurements provide information on the degree of salt accumulation in the substrate.

Monitoring data can be sent automatically to a data logger by remote data transmission.

EC represents the total concentration of salts in a solution. It is therefore a useful measure of the total salt content of the solution around the root zone in a soilless substrate. Yield response to moderate levels of salinity follows the Maas and Hoffman model.

Data interpretation

In agriculture, the Maas and Hoffman model is used to indicate the tolerance levels of different crops and their yield to soil salinity. Interpretation is based on the $\mathbf{EC_{se}}$. Generally, with increasing salinity, there is less production. When soil EC exceeds a species-specific threshold value, strategies to limit the salinity impact on yield should be considered.

[1] Fertigation Bible (FB), sections 10.17, 10.19, 11.9, 11.10 y 11.11 in [http://www.fertinnowa.com /](http://www.fertinnowa.com/)
[2] Visconti F. y de Paz, J. M. (2016). Electrical Conductivity Measurements in Agriculture: In "The Assessment of Soil Salinity". Capítulo 5. http://dx.doi.org/10.5772/62741