FACT SHEET

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Monitoring soil salinity for irrigated horticulture

Accumulation of salts in the root zone can have drastic effects on the growth and yield of horticultural crops. Further information on salinity impacts and managing soil salinity is contained in other PIRSA Fact Sheets (see *Further Reading* section at the end of this fact sheet).

Effects of Soil Salinity

Soil salinity has three adverse impacts:

- increasing salt in the soil increases the osmotic pressure. This results in reduced water availability and reduced growth.
- some elements or ions, especially sodium (Na), chloride (Cl) and boron (B), when in excess are toxic to crops.
- high proportions of sodium (Na) in relation to calcium (Ca) and magnesium (Mg) can adversely effect soil structure, and thus limit water, air and root movement in the soil.

Causes of Soil Salinity

The main factors causing high soil salinity levels are:

- high irrigation water salinity
- uneven water distribution
- under-watering - salts build up in the rootzone
- salinisation of rootzone from shallow watertables

Measuring Soil Salinity

Salinity is commonly measured by measuring the electrical conductivity (EC).of soil water or saturated paste extract. EC is measured in deciSiemens per metre (dS/m), which is equivalent to 1000 EC units. Soil water can be extracted by two techniques:

A. SoluSAMPLER™ Method

The SoluSAMPLER™ is an inexpensive device for extracting soil water and hence allows monitoring soil salinity throughout the season and hence adjustments can be made to irrigation management.

It is recommended that the SoluSAMPLER™ be installed in nests of three, positioned at depths of 30cm, 60cm and 90cm at the representative site within 15cm of a dripper (when dripper spacing is 60cm) or within the wetting zone of a sprinkler. More than one set will enhance the quality of data. Alternately, the SoluSAMPLER™ should be buried in middle of active root zone eg. 50cm for perennial crops (citrus, vines), and at 25cm for shallower rooted annual crops (vegetables). Soil water is drawn from the surrounding soil and into the ceramic cup (under vacuum), extracted by syringe, and the salinity (termed hereafter as ECsw) measured easily with a simple portable EC meter.

Soil salinity interpretation standards for the SoluSAMPLER™ are given in Tables 3 and 4. The SoluSAMPLER™ was developed by SARDI. For more information see the *Further Reading* section at the end of this fact sheet. If the soil is too dry, SoluSAMPLER™ will not yield sample. For dry soils, soil sampling method B will be required to measure salinity.

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B. Soil Sampling Method

The soil sample method requires simple tools such as a shovel or soil sampling auger, and no prior equipment purchase or setup. Since however this method is only done once or twice a year and requires a laboratory analysis. It may deliver salinity information when the damage is done, and there is also analysis cost by to consider.

a. Where to Sample

Deciding where to soil sample is dependent on the reason for sampling. There are several situations which may require different methods. For example:

- ***Analysis of soil salinity of an area prior to development -*** Select several sites which will adequately represent the variation within the area. Usually samples are taken from the top of dunes, midslopes and swales. At each site selected, dig three holes and bulk the samples from each depth.

- ***Perceived problems of high salinity at some places on a property -*** Examples are shallow watertable areas, uneven sprinkler patterns or individual trees declining in health. In these situations select three sites across the wetted area of the sprinkler, furrow or dripper. At each site selected, dig a hole and collect a sample for each depth. This process can be repeated in another area of the irrigation system and the samples for each site and depth bulked.

- ***Ongoing salinity monitoring -*** Samples should be taken on a regular basis (at least twice yearly) to ensure adequate leaching and effective irrigation system performance. Samples should be taken from the same sites each year, to allow monitoring of trends over time, and identify sudden changes.

b. When to Sample

Areas proposed for redevelopment or development should be sampled well before planting, so that soil amendments (eg. gypsum) can be spread, and leaching irrigations applied if necessary. Problem areas should be sampled as soon as possible when the problems are identified, so that remedial action can be applied. An ongoing sampling program is recommended to identify forthcoming problems before they affect crop growth and yield. Appropriate sampling times are late spring and autumn.

c. How to Sample

Soil samples are generally taken using a hand auger at depths of 25, 50, 75 and 100 cm, for perennial crops, (eg. citrus, vines), and at 10, 25 and 50 cm for shallower rooted annual crops (eg. vegetables). The sample depth can be changed for individual situations.

About 500 grams of soil is required for the test. The samples should preferably be transported in plastic bags (paper bags become soggy and break) with the grower name, sampling position, depth and date clearly marked on the bag, using a waterproof marker pen.

The samples should be transported to the laboratory as soon as practical to prevent any chemical changes occurring. The bags of soil can be sent to the Analytical Crop Management Laboratory (ACML) or private laboratories for analysis of soil salinity (specify the saturation paste extract method).

Interpretation of Soil Salinity Data

Soil salinity is normally related to the EC of the aqueous soil extracts, eg saturated soil-pastes (hereafter termed as ECe). Crop tolerance to salinity is generally expressed as ECe. ECsw measured by SoluSAMPLER™ was found to be twice that of the ECe.

▪ Interpretation of SoluSAMPLER™ ECsw for Crop Tolerance

A general salt tolerance level measured for various horticultural crops expressed as ECsw of samples extracted by SoluSAMPLER™ is reported in Table 1. Table 2 shows the relative salt tolerance of grape vines. The Tables show the approximate soil salt content of the SoluSAMPLER™ sample (expressed as the ECsw in dS/m), where 0, 25 and 50 percent yield decreases may be expected.

These critical values should be used as a guide only because ECsw may require adjustment depending on agronomic management, irrigation salinity, soil moisture content, variety, soil type and leaching efficiency.

▪ Interpretation of Soil ECe for Crop Tolerance

The ECe value is widely used as a measure of soil salinity because it is a reproducible value that is directly proportional to the salt concentration of the soil water. The ECe value can be evaluated against the criteria presented in Table 3 to assess the general level of crop tolerance for a particular irrigation situation.

A list of the relative salt tolerances of common horticultural cops is provided in Table 4. The Table shows the approximate soil salt content, expressed as the ECe (dS/m), where 0, 10, 25 and 50 percent yield decreases may be expected. This table is also meant as a general guide only.

Table 1: Soil salinity thresholds (ECsw in dS/m) for selected horticultural crops[1]

Crop	Soil water salinity threshold (ECsw) in dS/m		
	0% yield loss	25% yield loss	50% yield loss
Orange	3.4	6.6	9.6
Grapefruit	3.4	6.6	9.6
Lemon	3.4	6.6	9.6
Apricot	3.2	5.2	7.4
Peach	3.4	5.8	8.2
Carrot	2.0	5.8	9.2
Onion	2.4	5.6	8.6
Potato	3.4	7.6	11.8
Tomato	5.0	10.0	15.0

1 Modified after Ayers and Westcot (1985)

Table 2: Soil salinity thresholds (ECsw in dS/m) for winegrapes[1, 2, 3]

Salinity tolerance	Variety or rootstock	Soil salinity threshold (ECsw) in dS/m		
		0% yield loss	25% yield loss	50% yield loss
sensitive to moderately sensitive	Own roots (*Vitis vinifera*): eg. Sultana, Shiraz, Chardonnay Rootstocks: eg. 1202C, Kober 5BB, Teleki 5C, S04	3.6	8.8	14.0
moderately tolerant to tolerant	Rootstocks: eg Ramsey, 1103 Paulsen, Ruggeri 140, Schwarzmann, 101-14, Rupestris St George	6.6	11.8	17.0

1 *ECsw modified from Zhang et al. (2002)*

2 *A general rate of reduction for wine grapes is assumed (9.6% for each additional 1dS/m), based on Tanji & Kielen (2003)*

3 *Thresholds are based upon point measurements of soil ECsw (eg taken post harvest), and do not account for changes in soil salinity or crop salinity tolerance at different growth stages. Data is based on 5-6 year duration field trials and do not take into account longer term responses. It should be noted that some grapevine rootstocks eg K51-40 are particularly salt-sensitive and should be avoided.*

Table 3: General guide to soil salinity thresholds (ECe in dS/m)

Soil salinity threshold (ECe dS/m)	Interpretation
0 - 2	Salinity effects mostly negligible
2 - 4	Yields of very sensitive crops may be restricted
4 - 8	Yields of many crops restricted
8 - 16	Only tolerant crops yield satisfactorily
16 +	Only a very few tolerant crops yield satisfactorily

Table 4: Soil salinity thresholds for selected horticultural crops (ECe) in dS/m[1]

Crop	Soil salinity threshold (ECe dS/m)			
	0% yield loss	10% yield loss	25% yield loss	50% yield loss
Almond	1.5	2.0	2.8	4.1
Avocado	1.3	1.8	2.5	3.7
Citrus	1.7	2.3	3.3	4.8
Date Palm	4.0	6.8	11.0	18.0
Lucerne	2.0	3.4	5.4	8.8
Olive	2.7	3.8	5.5	8.4
Onion	1.2	1.8	2.8	4.3
Pistachio	4.0	4.5	5.0	6.0
Pomefruit	1.7	2.3	3.3	4.8
Potato	1.7	2.5	3.8	5.9
Stonefruit	1.7	2.2	2.9	4.1
Tomato	2.5	3.5	5.0	7.6
Vine	1.5	2.5	4.1	6.7

1 Adapted from Ayers and Westcot (1985)

References

Ayers, RS & Westcot, DW 1985, *Water Quality for Agriculture*, Irrigation and Drainage Paper 29 Rev. 1, Food and Agriculture Organization of the United Nations (FAO), Rome.

Tanji, KK & Kielen, NC 2003, *Agricultural drainage water management in arid and semi-arid areas*, FAO Irrigation and Drainage Paper 61, Food and Agriculture Organization of the United Nations (FAO), Rome.

Zhang et al 2002, 'Yield-salinity relationships of different grapevine (*Vitis vinifera* L.) scion-rootstock combinations', *Australian Journal of Grape and Wine Research*, 8:150-156.

Contacts

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SoluSAMPLER™ was developed by Dr Tapas Biswas of the South Australian Research & Development Institute (SARDI) see http://www.sardi.sa.gov.au/pdfserve/water/products_and_services/swe_web.pdf and marketed by Sentek Sensors Technologies, Stepney SA http://www.sentek.com.au

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Further Reading

Managing Salinity with Restricted Allocations in the South Australian Riverland (PIRSA Fact Sheet No. 04/07)
Salinity impacts of low Murray River flows in the South Australian Riverland (PIRSA Fact Sheet No. 05/07)
http://www.pir.sa.gov.au/pirsa/drought/irrigation__and__water_management/salinity_management

Water Budgeting Guidelines (PIRSA Fact Sheets for selected horticulture crops)
Water Budgeting & Water Trade Decisions Tools (PIRSA Spreadsheets)
http://www.pir.sa.gov.au/pirsa/drought/irrigation__and__water_management/water_budgeting_and_water_trade_decision_tools

Drought Strategy Checklist (PIRSA Fact Sheet 19/06)
Irrigating Horticulture Crops with Reduced Water Supplies (PIRSA Fact Sheet 18/06)
http://www.pir.sa.gov.au/pirsa/drought/irrigation__and__water_management/irrigated_crop_information

Business Decision Making Tool (PIRSA Spreadsheet)
http://www.pir.sa.gov.au/pirsa/drought/irrigation__and__water_management/business_decision_making_tool

Irrigators Toolkit, Latest River Murray Information, Government Assistance and Support
http://www.pir.sa.gov.au/pirsa/drought/irrigation__and__water_management

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