SUSTAINABLE
IRRIGATION MANAGEMENT UPDATE

Salinity Management Practice Guidelines

Managing root-zone salinity for irrigated horticultural crops in winter rainfall zones of Australia

Tapas Biswas, John Bourne, Gerrit Schrale and Michael McCarthy

NATIONAL PROGRAM FOR
Sustainable Irrigation

Published by:	National Program for Sustainable Irrigation Land & Water Australia
Postal address:	GPO Box 2182, Canberra, ACT 2601, Australia
Office location:	Level 1, Phoenix Building, 86 Northbourne Avenue, Braddon ACT 2612, Australia
Telephone:	02 6263 6000
Internet:	www.npsi.gov.au
Printed by:	Paragon Printing
Designed by:	Meta Design Studio, Canberra ACT

Disclaimer

The information contained in this publication is intended for general use, to assist public knowledge and discussion and to help improve the sustainable management of land, water and vegetation. It includes general statements based on scientific research.

Readers are advised and need to be aware that this information may be incomplete or unsuitable for use in specific situations. Before taking any action or decision based on the information in this publication, readers should seek expert professional, scientific and technical advice.

To the extent permitted by law, the Commonwealth of Australia, Land & Water Australia (including its employees and consultants), the authors, South Australian Research & Development Institute, the National Program for Sustainable Irrigation and its partners do not assume liability of any kind whatsoever resulting from any person's use or reliance upon the content of this publication.

National Program for Sustainable Irrigation

The National Program for Sustainable Irrigation focuses research on the development and adoption of sustainable irrigation practices in Australia. The Program has sixteen funding partners

South Australian Research & Development Institute

SARDI Water Resources & Irrigated Crops, GPO Box 397, Adelaide 5001

Publication information

Product Code: PN22225

ISBN: 9781921544330 (print) 9781921544347 (online)

Date: March 2009

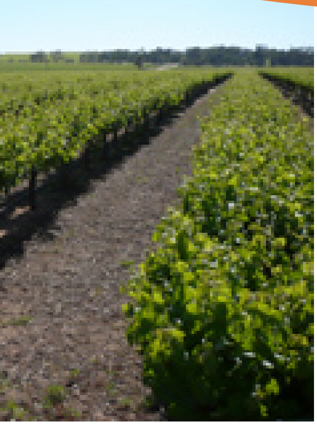
The research team would like to acknowledge the contribution of the following organisations:

Centre for Natural Resource Management, South Australia
National Action Plan for Salinity and Water, Australian Government
South Australian Murray-Darling Basin Natural Resource Management Board
New South Wales Department of Primary Industries
Victoria Department of Primary Industries
Murray Darling Basin Commission
Cooperative Research Centre for Irrigation Futures
Constellation Wines Australia
Foster's Group
Cooperating Growers

Photos provided courtesy of South Australian Research and Development Institute

TABLE OF CONTENTS

QUICK REFERENCE GUIDE . . . . INSERT
IRRIGATION AND ROOT-ZONE SALINITY 1
WHY IRRIGATORS NEED TO MEASURE ROOT-ZONE SALINITY 2
ROOT-ZONE SALINITY THRESHOLDS 3
MEASURING ROOT-ZONE SALINITY 5
Equipment to measure root-zone salinity 5
Setting up a typical suction cup sampling protocol under drip irrigation 7
Other complementary measurements 7
Seasonal variation in root-zone salinity 8
MEASURING ROOT-ZONE SALINITY FROM IRRIGATION WATER . . . 10
HOW TO MANAGE ROOT-ZONE SALINITY 11
Winter leaching following rainfall 11
How much water to apply in a leaching irrigation 11
Leaching when there are shallow, saline water-tables present 12
OTHER ISSUES TO CONSIDER 13
The effects of nutrients and fertiliser on root-zone salinity 13
Root-zone salinity and soil problems. 13
FINAL WORD AND SOME CONSIDERATIONS 14
IMPORTANT CONTACTS 15
REFERENCES 15



Key messages for managing root-zone salinity for irrigated horticultural crops in winter rainfall zones

- All irrigation water contains some amount of salt. Because plants exclude most salt in taking up water from the soil, salt levels increase under continual irrigation. This salt is usually removed by flushing the root-zone with extra water.
- Irrigators now apply water to accurately meet crop needs in order to achieve high water-use efficiency. This has meant a reduction in the amount of water flushing through the root-zone and salt levels are rising in horticultural crops in many major irrigation districts, even with efficient management.
- Current drought conditions and low water allocations could mean even less water being available for flushing. If irrigation water is saline, the need to actively remove salt from the root-zone is critical.
- There are now new tools available to irrigators to assist them measure and monitor root-zone salinity over time. Tools such as suction cups and wetting front detectors allow on-going measurement instead of relying only on soil testing.
- Leaching of salts from the root-zone remains the most effective technique for salt management. However, recent research has shown that the leaching process is complex and not always completely effective.
- Winter leaching to complement rainfall appears to be the most practical way to reduce root-zone salinity levels. Some indicative thresholds have been established for a range of horticultural crops, and irrigators should aim to keep at or below these levels for optimum production in most cases.

IRRIGATION AND ROOT-ZONE SALINITY

A better understanding of plant requirements and the highly efficient management of water has led irrigators to apply water to accurately meet crop needs. This has meant a considerable reduction in the amount of water flushing through the root-zone. As a result, soil salinity levels have risen. Current drought conditions and low water allocations are likely to result in even less water being used to flush salts from the root-zone. The declining quality of water resources means that actively removing salt from the root-zone is even more important.

In order to manage root-zone salinity, you need to be able to accurately measure salt levels in the root-zone to monitor salinity trends over time. In districts with low salinity problems, this can be done through annual soil sampling. In districts with increasing salinity problems new on-going direct sampling methods, such as suction cups and wetting front detectors, are being used by irrigators to enable them to make continual adjustments in their management practices.

Leaching of salts from the root-zone remains the most effective technique for salt management. However, recent research has shown that the leaching process is complex and not always completely effective. This is thought to be due to the presence of preferred pathways of water movement through the soil, which results in salt build-up in other parts of the root-zone. The build-up of salt in the root-zone can also affect soil structure, further limiting the effectiveness of leaching, so irrigators need to consider soil as part of their irrigation management.

Winter leaching to complement rainfall appears to be the most practical way to reduce root-zone salinity levels. Some indicative thresholds have been established for a range of horticultural crops, and irrigators should aim to keep at or below these levels for optimum production in most cases.

Figure 1. Leaf death in a well managed vineyard, due to increased root-zone salinity.

WHY IRRIGATORS NEED TO MEASURE ROOT-ZONE SALINITY

High salinity has been the downfall of irrigation schemes since ancient times. The factor most likely to limit long-term sustainability is lack of drainage of excess saline water away from the root-zone.

Irrigation water usually contains dissolved salts, whether from surface supplies or groundwater. In taking up this water plants exclude much of the salt, which then slowly builds up in the root-zone. Once this salt builds up beyond a certain threshold, plant production is reduced. At higher levels salt can be toxic to plants as well as causing osmotic effects that reduce the availability of soil water to plant roots.

The unit of salinity measurement is deci-Siemens per metre or dS/m. Salinity is sometimes measured in electrical conductivity units or EC units. 1dS/m is equivalent to 1000 EC units or 640 mg/litre (ppm) of dissolved salts.

The easiest way to remove salt is by applying additional water above what is needed by the crop to flush, or leach, the salt to below the root-zone. The process of leaching can be quite complex, for example even low river salinity levels in the Riverland of South Australia have resulted in salinity building up in the root-zone, with field measurements up to double that expected despite high levels of management such as with drip irrigation. This is because the leaching water is not removing as much salt as expected.

The effectiveness of leaching may be affected by water moving through the root-zone along preferred pathways like large cracks or old root channels, and leaving some salt behind. In this case additional leaching water may be required. Many irrigators apply water to exactly meet crop needs, achieving high levels of water use efficiency, but risking the long-term sustainability of the crop due to increasing root-zone salinity and crop failure (Figure 1).

Once root-zone salinity threshold levels are exceeded, irrigators should take action to reduce salinity levels. Prior to reaching these levels, salinity trends should be regularly monitored and managed.

In areas that have winter rainfall, leaching may be more effective than leaching during the summer irrigation season. This is because the preferred pathways, like large cracks, are less likely following winter rainfall when soils are wet and have "closed up".

ROOT-ZONE SALINITY THRESHOLDS

Many studies have been carried out to measure the effect of increasing soil salinity on crop yield. Yields appear to remain constant up to a certain salinity value, called the "threshold value", and then begin to reduce. These threshold values are averaged over the root-zone for the whole of the growing season. The threshold value and the rate of reduction vary for different crops, and sometimes vary between crop varieties.

To maintain best economic return, salinity levels should be kept below these thresholds to provide for maximum plant production. For some crops reduced yields may be associated with higher quality and greater returns. In this case a slightly higher threshold may be more appropriate. For example wine-grape growers may aim to produce only 70-75% of maximum yield, to ensure good wine quality. Where salt tolerant root-stocks are available then an even higher threshold may be used.

Table 1 below is a list of thresholds expressed as the electrical conductivity of soil water (ECsw) for maximum production of major horticultural crops, and likely yield reductions from higher salinity levels. Table 2 is a summary of thresholds for wine-grapes, including grapevine root-stocks. Table 1 & 2 have been derived from Maas and Hoffman[1] and Zhang *et al*[2] respectively. These values were calculated using the relationship between soil saturated paste electrical conductivity (ECe) and the salinity by the suction cup soil water extractor developed by SARDI. The suction cup salinity values (ECsw) have been found to be approximately twice ECe when calibrated in a drip irrigated sandy loam vineyard in the Riverland. The SARDI suction cup water extractor is now marketed under the brand name of SoluSAMPLER by Sentek Sensor Technologies (www.sentek.com.au).

If other methods of measurement (or similar equipment for measuring soil water EC) are used, different thresholds may need to be determined in relation to the saturated paste standard.

Table 1: Horticultural Crop Thresholds (ECsw) for Root-zone Salinity as measured by the SARDI suction cup.

Crop	Threshold for maximum production[2&3] (dS/m)	Threshold for reduced yield levels (dS/m)
	100% yield	**75% yield**
Orange	3.4	6.6
Grapefruit	3.4	6.6
Lemon	3.4	6.6
Apricot	3.2	5.2
Peach	3.4	5.8
Carrot	2.0	5.8
Onion	2.4	5.6
Potato	3.4	7.6
Tomato	5.0	10.0

Table 2: Wine Grape Thresholds (ECsw) for Root-zone Salinity as measured by the SARDI suction cup.

Variety or root-stock	Threshold for maximum production[2] (dS/m)	Threshold for reduced yield levels[4] (dS/m)
	100% yield	**75% yield**
Sensitive to Moderately Sensitive Own roots (*Vitis vinifera*): e.g. Sultana, Shiraz, Chardonnay,. Rootstocks: e.g. 1202C, Kober 5BB, Teleki 5C, S04	3.6	8.8
Moderately Tolerant to Tolerant Rootstocks: e.g. Ramsey, 1103 Paulsen, Ruggeri 140, Schwarzmann, 101-14, Rupestris St. George.	6.6	11.8

The threshold values given in Tables 1 & 2 are only a guide at this stage, and further research is required to finetune the values.

The thresholds in Table 2 above are based upon point measurements e.g. taken postharvest, and do not account for changes in soil salinity or crop salinity tolerance at different growth stages. Perennial horticultural crops are considered most sensitive to salinity between flowering and rapid fruit growth stages. Also, the data are based on 5-6 year duration field trials and do not take into account longer term responses. For example, in a report on salinity impact to the Murray-Darling Basin in 1999, Gutteridge, Haskins and Davey[5] consultants proposed that the response of grapevine yield to soil salinity greater than the threshold be weighted such that the rate of yield decline per dS/m after eight years exposure was double that in the first seven years of exposure.

It should also be noted that some grapevine rootstocks, e.g. K51-40, are particularly salt-sensitive and should be avoided. Annual vegetable crops appear more sensitive at germination and in the early seedling stage, particularly if salt concentration is highest at the surface. Until further research is done annual threshold values are appropriate targets.

Figure 2. Sampling soil water from the root-zone and testing in the field with a portable EC meter.

MEASURING ROOT-ZONE SALINITY

Until recently root-zone salinity has been measured in the laboratory, using a saturated paste made from the soil. Equipment is now available to directly obtain a sample of representative soil water, which can be measured using a field electrical conductivity (EC) meter (Figure 2). Field electrical conductivity meters need initial calibration and periodic checking of the calibration. Instructions are provided with the meter.

In order to measure and monitor soil salinity to evaluate the need for a leaching irrigation you will need to consider what equipment to use, how to set it up, how often to take the measurements, and are there any other complementary measurements that can be taken. When evaluating these results you need to consider what seasonal variation in root-zone salinity to expect.

Equipment to measure root-zone salinity

By taking soil samples in the field and sending them to the laboratory soil salinity can be measured by either a saturated soil-paste extract or a 1:5 soil to water suspension (Figure 3). These methods are suitable to check root-zone values annually, where salinity is not a significant problem. However, they do not provide on-going monitoring of salinity levels throughout the year. Taking many soil samples and sending to a laboratory is time consuming and costly. A better alternative is direct soil measurement on-the-spot.

There are now several types of equipment that irrigators can use to directly measure root-zone salinity throughout the year. Being able to measure and monitor salinity levels throughout the year is useful where salinity is an increasing problem and on-going changes need to be monitored.

Suction cups

A suction cup is a custom designed ceramic cup glued to a short length of casing, housing an extraction tube with a two-way stopcock. It is used to extract soil water over a range of soil moisture conditions from 0-100 kPa. Once under vacuum, the suction cup draws moisture from the surrounding soil and stores it in the inert ceramic cup (Figures 4 & 5).

The advantage of using suction cups is that they allow growers to monitor salinity levels frequently, which gives a better idea of the actual variation in soil salinity as it occurs. This information can assist in making management decisions and may help prevent potential salinity problems.

Figure 3. Soil sampling and laboratory analysis for root-zone salinity.

Figure 4. SARDI suction cup

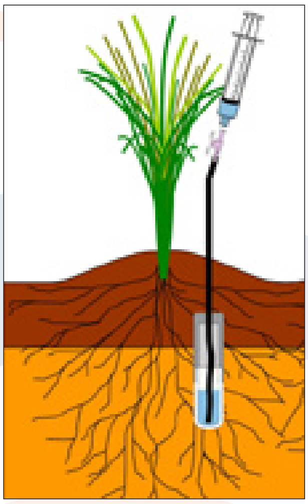


Figure 5. Suction cup buried within the root-zone

Figure 6. Wetting front detector

Wetting front detectors

A specially shaped funnel and filter is buried at the required depth, and collects soil water as the wetting front of an irrigation reaches this depth (Figure 6). The wetting front detector needs to be placed at depths where there will be fairly strong wetting fronts from irrigation, because it samples when the soil is wetter than 3 kPa (for guidance on depths see www.fullstop.com.au). The arrival of the wetting front is indicated by a float mechanism fitted into the funnel and reaching to the surface. A soil water sample can also be obtained from the wetting front detector, through a piece of flexible tubing that is connected to the base of the funnel at installation. The tubing runs up through the soil and ends above ground level. Samples from both suction cups and wetting front detectors are removed using a plastic syringe. The wetting front detector was designed to monitor water movement through the soil to assist irrigation scheduling. In addition, growers are beginning to use the tool to monitor nutrients and salt.

Other equipment currently available is based on electrical resistance, conductance or capacitance.

Figure 7. A group of three suction cups located 15cm from a dripper.

Setting up a typical suction cup sampling protocol under drip irrigation

- Typically suction cups are placed at 30, 60 and 90 cm in a root-zone of 1 metre, and located about 15 cm from a dripper along the drip line. Placement of cups may vary depending on soil texture in the profile. Measurements from these three depths give a value for average root-zone salinity. As a minimum place one cup in the middle of the root-zone as this is where the largest variation in salinity usually occurs (Figure 7).
- Where water is applied evenly through a dripper system, then only one set of suction cups is needed. Install additional sets if there are major changes in soil type within a block.
- Suction is created in the cup, by using a syringe, approximately 1 day after irrigation, and a soil water sample is collected in the next day or two.
- Take measurements fortnightly during the peak of the irrigation season in summer, to observe the maximum values reached. These should not exceed thresholds determined for the specific crop or situation. Several winter measurements should be made to show the annual variation occurring, and to assess the effectiveness of winter leaching rainfall.

A manual with further installation and operation instructions for the suction cup is available from Sentek Sensor Technologies.

Other complementary measurements

Irrigators should consider using additional measurements to complement root-zone salinity. This could include:

- Calibration of root-zone salinity with salinity estimates from electro-magnetic (EM) surveys, now commonly used in horticultural enterprises, may help to provide an assessment of any spatial variation of root-zone salinity.
- Plant tissue measurements of sodium or chloride. These should be used with caution as the correlation between plant and soil measurements of salinity is not always high. It appears that soil measurements provide a better early warning of potential salinity problems.
- Direct soil water measurements or soil water balance calculations based on climatic estimates of crop water use. By tracking soil moisture levels in the root-zone over the irrigation season not only can future irrigations be scheduled, but estimates of deep drainage under the crop can be made. A low level of deep drainage may indicate potential salt build-up.

Seasonal variation in root-zone salinity

Figure 8 shows the annual variation of root-zone salinity under a drip irrigated vineyard at Currency Creek in the Lower Lakes district of South Australia, using saline water (average of 3.7 dS/m, 2006/07). These measurements were taken using a SARDI suction cup.

Suction cups were installed at 30, 60, and 90 cms, however only the average of the three depths is shown in Figure 8. Root-zone salinity varied from a low of about 4dS/m after winter rains and at the beginning of the growing season, to a high of about 11dS/m at the end of the season.

A significant summer rainfall event and a summer leaching irrigation in February had little effect on reducing salinity values compared to winter rainfall.

The average root-zone salinity for the whole of the growing season was above the threshold for sensitive or moderately sensitive varieties under maximum production, but acceptable for varieties on a salt tolerant rootstock.

If sensitive or moderately sensitive varieties are being grown, then an additional winter leaching in July when the salinity of irrigation water was much lower than during the irrigation season, could reduce soil salinity significantly. Average seasonal root-zone salinity may then be reduced so that no yield losses occur with these varieties.

The seasonal variation using lower salinity water would be of a similar pattern but with lower minimum and maximum values. For example, a variation in the Riverland using water of only 0.5 dS/m could be between 1.0 and 4.0 dS/m.

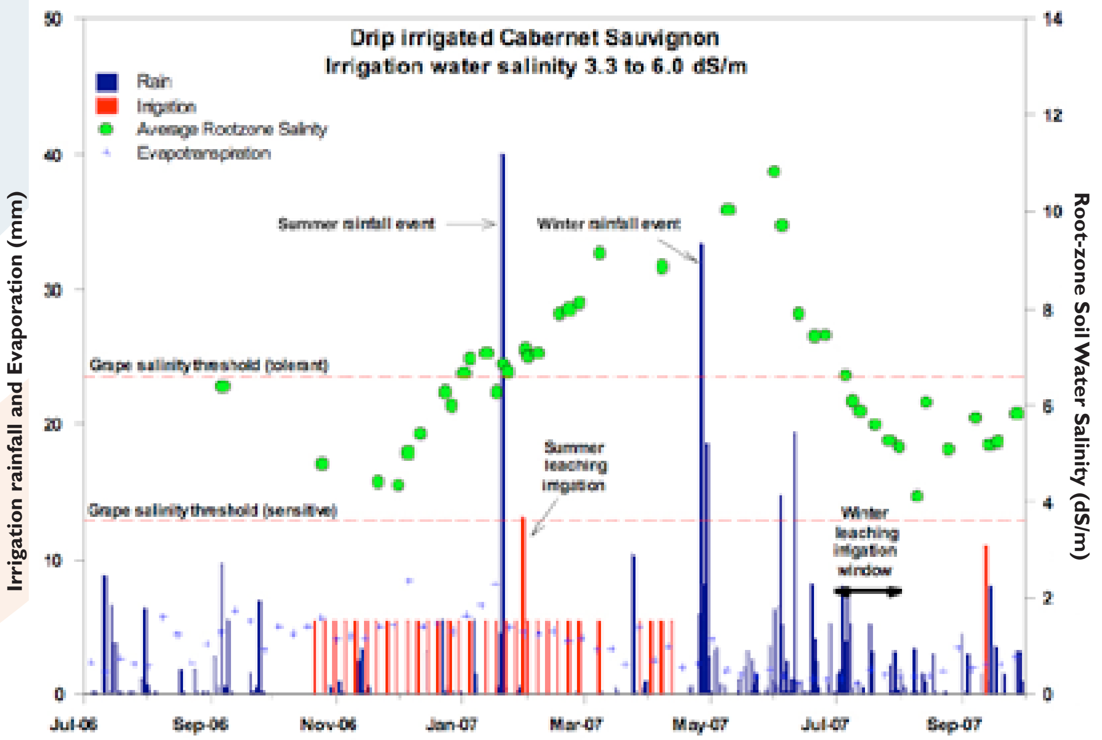


Figure 8. Measurements of root-zone salinity during 2006-07 at Currency Creek

The results of an early spring leaching in a drip irrigated commercial vineyard in South Australia[6], are shown in Figure 9. Due to high root-zone salinity in 2007, three 8-hour irrigations were applied between the 12th – 14th September 2008, to complement 10 mm rainfall. Measurements with suction cups before and after irrigation showed a 10% decrease in root-zone salinity at 25cm, 33% at 50 cm, and 25% at 75 cm.

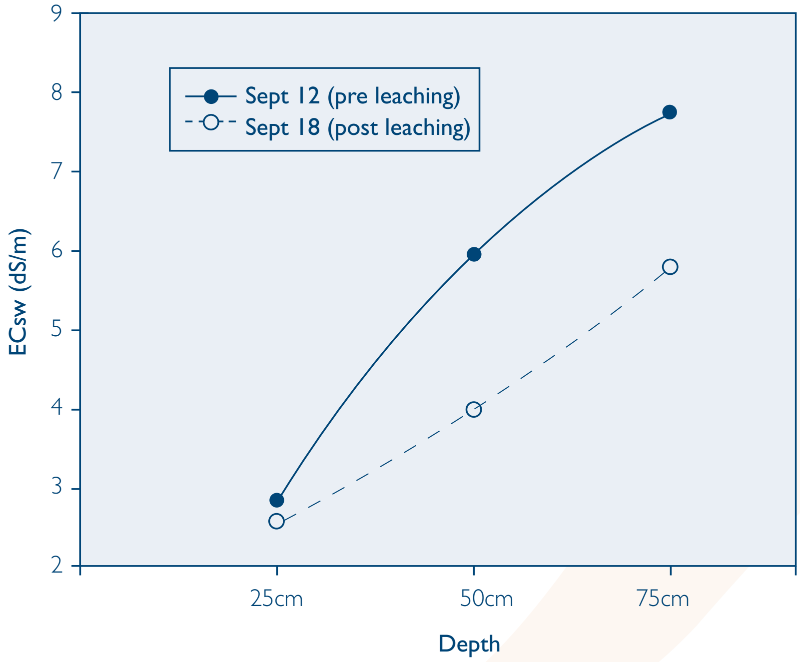


Figure 9. Reductions in root-zone salinity after an early spring leaching.

MEASURING ROOT-ZONE SALINITY FROM IRRIGATION WATER

Root-zone salinity levels, irrespective of crop type, can also be estimated simply from the salinity of irrigation water, by making some assumptions about the depth of the root-zone, evapo-transpiration, the way water is taken up by plants, and the amount of leaching carried out. This can give a broad indication to irrigators whether they are likely to have a problem or not, and if they should start an active monitoring program.

Table 3 developed by SARDI shows potential root-zone salinity values for a range of situations. It assumes that the leaching volume applied is in addition to season crop water use requirements. For example, if 15% of the total water applied in a season is not used by the crop, but drains below the root-zone and removes salt, then this is considered 15% leaching. In this case 85% of the total water applied is used by the crop. This is often used as a measurement of field water use efficiency.

Table 3. Estimates of average root-zone salinity, from a range of irrigation water salinities and leaching volumes for a root-zone of 1 metre, under sprinkler irrigation.

Irrigation water salinity (dS/m)	Average root-zone salinity with 10% leaching (dS/m)	Average root-zone salinity with 15% leaching (dS/m)	Average root-zone salinity with 20% leaching (dS/m)
0.2	1.1	0.8	0.7
0.4	2.1	1.7	1.4
0.6	3.2	2.5	2.1
0.8	4.3	3.3	2.8
1.0	5.3	4.1	3.5
1.5	8.0	6.2	5.3
2.0	10.6	8.2	6.9
2.5	13.3	10.3	8.6

The figures in Table 3 account for the leaching process being not completely efficient. Based on field measurements in the Riverland of South Australia, a leaching efficiency of 70% has been assumed in the table. That is, that only 70% of the water interacts with the salt to leach it through the soil profile.

By comparing the average root-zone salinities in this table with the thresholds in Tables 1 & 2, yield reductions for many crops would appear to begin in the range 0.6-0.8 dS/m irrigation water salinity. Higher values can be tolerated with more leaching, or salt tolerant strains.

Many factors influence root-zone salinity and so for best management it is necessary not just to rely on general figures such as in Table 3, but to make direct measurements in the field.

HOW TO MANAGE ROOT-ZONE SALINITY

Winter leaching following rainfall

Experience has shown that leaching irrigations during the growing season, for example at the end of the summer, have not always been effective in reducing soil salinity. This may be due to water moving along preferred pathways as described previously.

A better approach to improving the efficiency of leaching, especially in winter rainfall zones, is to carry out leaching irrigations in winter, for example in July. This is the time of the year when crops are dormant, evapo-transpiration is low and rainfall has occurred. This will minimise the chance of any upward flow in the soil profile that could counteract the effect of leaching. Irrigating at night may also further reduce evapo-transpiration.

The effectiveness of this winter leaching can be improved by intermittent application of small volumes of water onto wet soil.

An example protocol during winter could include:

- Measure root-zone salinity 2-3 days after at least 15-20mm rainfall in one week.
- Check the reading against crop thresholds, or a target threshold that is acceptable.
- Apply one or several small leaching irrigations, and recheck root-zone salinity.

How much water to apply in a leaching irrigation

When root-zone salinities are above threshold values then best management practice should aim to reduce values to the threshold or slightly below at the beginning of each irrigation season.

Irrigators already often apply water just prior to the season to ensure crops are not water stressed. This practice could easily be extended to include salinity reduction. The question then becomes, how much water to apply?

In Table 3, an estimate of root-zone salinity was made assuming different amounts of leaching. However if the root-zone salinity can be measured directly with a suction cup, then the table can also indicate an approximate amount of leaching required. For example, with an irrigation water salinity of 0.6dS/m and 15% leaching, Table 3 suggests a potential root-zone salinity of 2.5dS/m. Alternatively, if water salinity is 0.6dS/m and we want root-zone salinity with a suction cup to be 2.5dS/m, then we need 15% leaching.

The calculation actually uses a number of climate and plant factors and so to make this easier SARDI has made a leaching calculator available for use by irrigators. The calculator can be accessed on the SARDI webite at www.sardi.sa.gov.au under the section 'Water Resources and Irrigated Crops'.

Leaching when there are shallow, saline water-tables present

The leaching process can be hindered if a shallow water-table is present in or just below the root-zone. The best alternative in this situation is to install sub-surface drainage below the water-table, to remove the saline water.

Surface cover of at least 30% can also help reduce salt accumulation in the root-zone, especially where a saline water-table is present (Figure 10). Surface crop residues reduce evaporation from the soil surface, and subsequent upward water movement from the water-table.

Figure 10. Surface cover (e.g. perennial grass) can hep reduce salt accumulation in the root zone.

OTHER ISSUES TO CONSIDER

The effects of nutrients and fertiliser on root-zone salinity

Irrigators apply high levels of fertiliser before and during the growing season. Experiences in measuring root-zone salinity indicate that a spike is often seen following the application of fertiliser. This is because high levels of nutrient contribute to the electrical conductivity reading of the sample taken from a suction cup. In managing salt levels individual spikes due to nutrients should be disregarded.

Further research is needed to determine what proportion of the spikes are due to nutrients, such as nitrate, or are due to salinity caused by salts in the water. Understanding this will enable irrigators to manage nutrients as well as salt in the future. There will always be a balance between applying water to leach salts from the root-zone, but not too much so you can retain nutrients applied.

Root-zone salinity and soil problems

Over time, irrigation with poor quality water can cause a decline in soil structure. For example, high sodium levels in irrigation water may mean that sodium builds up on clay particles in the soil, resulting in a sodic soil. When rain or freshwater comes in contact with sodic soil, it disperses or "explodes" into many tiny particles, which can block soil pores that usually conduct water.

Sodic soils are those that have a high level of exchangeable sodium relative to calcium & magnesium.

If sodic clay is located in the surface soil, then irrigation or rainfall may simply run off without entering the soil. If the clay is deeper, then a barrier preventing water penetration may form, and water may move laterally across the clay surface instead of moving through the soil to plant roots. Sodic soils are also difficult for plant roots to penetrate.

Effective leaching always depends on the maintenance of good soil structure to allow water to move through the root-zone.

A simple way to show the decline of soil structure is to measure the sodium adsorption ratio (SAR) of the soil water solution collected in a suction cup. The SAR measures the ratio of sodium to calcium plus magnesium. Table 4 gives the suggested critical range of SAR measures in soil water[7]. These values are derived from research.

Table 4. Suggested critical soil water SAR for structure stability.

Sodicity Hazard	SARsw	Soil microstructure stability
Non-sodic	0-9	Generally stable.
Moderately sodic	9-21	Damaged when wet.
Highly sodic	>21	Spontaneous damage from irrigation or rain.

Taking good care of soil structure

Some simple management practices to improve soil structure include:

- Building up soil organic matter, by returning plant material or adding extra organic material.
- In permanent mounded horticultural plantings, planting perennial grasses along the drip line has significantly increased soil water penetration. This is due to the fibrous grass roots physically opening up the soil as well as providing a local source of organic matter.
- Application of gypsum to the surface or applied in the irrigation water if surface and/or sub-soils are sodic (Figure 11).

FINAL WORD AND SOME CONSIDERATIONS

There is now growing evidence that root-zone salinity is increasing under other-wise efficiently managed systems in many irrigation areas across southern Australia.

Leaching of the root-zone is the main management option available, although recent research indicates that the leaching process can be quite complex and does not actually remove all salts from the soil profile.

There is a need for irrigators to actively monitor root-zone salinity as part of their regular management, to identify relevant crop thresholds as a trigger point, and to pro-actively reduce salinity levels when thresholds have been exceeded.

If root-zone salinity is not managed, not only will there be short-term reductions in economic returns, but longer-term natural resource impacts, such as a decline in soil structure. Continued research is needed in this area, and field programs are being actively supported by the National Program for Sustainable Irrigation.

Figure 11. Application of a gypsum product to a sodic soil.

Climate change projections for the higher winter rainfall zones suggest a warming, drying trend is likely in the future. Such conditions may increase reliance on irrigation water for some horticultural systems and potentially decrease the leaching effects of winter rainfall. Policy- makers need to consider the impact of increasing salinity, and encourage irrigators to manage root-zone salinity by including it in future water allocations.

IMPORTANT CONTACTS

1. SARDI Water Resources & Irrigated Crops, Sustainable Systems, GPO Box 397, Adelaide SA 5001. Telephone 08 8303 9400. www.sardi.sa.gov.au
2. PIRSA Irrigated Crop Management Service, PO Box 411, Loxton SA, 5333. Telephone 08 8595 9138. www.pir.sa.gov.au
3. South Australian Murray Darling Basin Natural Resources Management Board, PO Box 2343, Murray Bridge SA 5253. Telephone 08 8532 1432. www.samdnrmb.sa.gov.au
4. Sentek Sensor Technologies, 77 Magill Road, Stepney SA 5069. Telephone 08 8366 1900. www.sentek.com.au
5. Grape and Wine Research and Development Corporation, PO Box 221, Goodwood SA, 5034. Telephone 08 8273 0500. www.gwrdc.com.au
6. Land and Water Australia, 86 Northbourne Avenue Braddon, ACT 2612. Telephone 02 6263 6000 www.lwa.gov.au
7. Victorian Department of Primary Industries, Sunraysia Horticultural Research Station, Irymple VIC 3498. Telephone 03 5051 4500. www.dpi.vic.gov.au
8. NSW Department of Primary Industries, Dareton Agricultural Research and Advisory Station, PO Box 62, Dareton NSW 2717. Telephone 03 5019 8400. www.dpi.nsw.gov.au

REFERENCES

1. Maas E.V. and Hoffman G.J. (1977), "Crop salt tolerance – current assessment". J.Irrig & Drainage Div., ASCE 103(IR2): 115-134.
2. Zhang et al (2002), "Yield-salinity relationships of different grapevine (Vitus Vinifera) scion-rootstock combinations". Aus J. Grape and Wine Research, 8: 150-156.
3. Schrale G.S. and Biswas T.K. (2004), "Salinity impact on Lower Murray Horticulture", DEP15 Stage 1 Report to Land and Water Australia (NPSI).
4. Walker R. (2008), CSIRO Merbein Vic, personal communication.
5. Gutteridge, Haskins and Davey Pty Ltd, Consulting Engineers (1999), "Salinity Impact Study – Final Report", Murray Darling Basin Commission.
6. DeGaris K. (2008), Constellation Wines Australia, Padthaway SA, personal communication.
7. Rengasamy P., Chittleborough D. and Helyar K. (2003), "Root-zone constraints and plant-based solutions for dryland salinity". Plant and Soil, 257: 249-260.

About the Program

The National Program for Sustainable Irrigation defines and invests in research on the development and adoption of sustainable irrigation practices in Australia. The aim is to address critical emerging environmental management issues, while generating long-term economic and social benefits that ensure irrigation has a viable future.

The Program has 16 funding partners:

Australian Government Department of Environment and Water Resources, Cotton Research & Development Corporation, Gascoyne Water Asset Mutual Co-operative, Gascoyne Water Co-operative, Goulburn-Murray Rural Water Corporation, Grains Research & Development Corporation, Harvey Water, Horticulture Australia Limited, Land & Water Australia, Lower Murray Water, Ord Irrigation Asset Mutual Co-operative, Ord Irrigation Co-operative, South Australian Research and Development Institute, Sugar Research & Development Corporation, Sunwater, and Western Australia Department of Water.

The program is managed by Land & Water Australia on behalf of the Partners.

The research team would like to acknowledge the funding for this project was provided by:

NATIONAL PROGRAM FOR Sustainable Irrigation

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

gwrdc GRAPE AND WINE RESEARCH AND DEVELOPMENT CORPORATION

QUICK REFERENCE GUIDE

Steps to measure, monitor and manage root-zone salinity in horticultural crops in the winter rainfall zones of Australia.

Step 1: Soil testing to see if there is a problem.

- Use standard soil sampling techniques to obtain a representative sample from different soil types or from specific problem areas on the property.
- Samples should be taken at different depths in the root-zone, eg. 25, 50, 75 and 100 cm for perennial crops, and 10, 25 and 50 cm for shallow-rooted annual crops.
- Samples should be taken at the beginning and end of the growing season, e.g. in late Spring and again in Autumn.
- Send samples to a laboratory for testing of the saturated paste extract salinity (cost approx $30 per sample – SARDI 2009).

Step 2: Check results against soil water electrical conductivity crop thresholds.

Tables 1 & 2 are suitable if suction cups are used for measuring salinity. If using a saturated paste extract, multiply the salinity reading of the extract by 2 and then check the results against the values given in Tables 1 & 2.

- If results indicate low salinity, continue soil testing each year to monitor changes over time.
- If results are above or close to thresholds, set up on-going measurements.

Step 3: Setting up on-going measuring equipment, e.g. using suction cups with drip irrigation.

- Place suction cups at 30, 60 and 90 cms in a root-zone of 1 metre, located about 10-15 cms from a dripper, along the drip line. Placement of cups may vary depending on soil texture in the profile.
- Take the average value of these 3 depths, or place one cup in the middle of the root-zone as this is where the largest variation in salinity usually occurs.
- Install additional sets of suction cups if there are major changes in soil type within the block.
- Apply suction to the cup 1 day after irrigation, and collect a soil water sample in the next day or two.
- Use a calibrated field electrical conductivity meter to measure salinity of soil water.
- Take measurements fortnightly during the peak of the irrigation season in summer, and monthly measurements during winter to show the annual variation. Estimate an average value for salinity for the whole season.
- Refer to installation manual available from Sentek Sensor Technologies.

Step 4: Carry out winter leaching if needed.

- Leaching is needed if the season salinity is above the crop threshold, or a target threshold that is acceptable.
- Optimum time for leaching is generally end of July.
- Measure root-zone salinity, 2-3 days after at least 15-20mm of rainfall in one week.
- Use SARDI leaching calculator to estimate total amount of leaching required.
- Apply small, frequent leaching irrigations, and recheck root-zone salinity until target is achieved.

Table 1: Horticultural Crop Thresholds (ECsw) for Root-zone Salinity as measured by the SARDI suction cup.

Crop	Threshold for maximum production (dS/m)	Threshold for reduced yield levels (dS/m)
	100% yield	**75% yield**
Orange	3.4	6.6
Grapefruit	3.4	6.6
Lemon	3.4	6.6
Apricot	3.2	5.2
Peach	3.4	5.8
Carrot	2.0	5.8
Onion	2.4	5.6
Potato	3.4	7.6
Tomato	5.0	10.0

Table 2: Wine Grape Thresholds (ECsw) for Root-zone Salinity as measured by the SARDI suction cup.

Variety or root-stock	Threshold for maximum production (dS/m)	Threshold for reduced yield levels (dS/m)
	100% yield	**75% yield**
Sensitive to Moderately Sensitive Own roots (*Vitis vinifera*): e.g. Sultana, Shiraz, Chardonnay,. Rootstocks: e.g. 1202C, Kober 5BB, Teleki 5C, S04	3.6	8.8
Moderately Tolerant to Tolerant Rootstocks: e.g. Ramsey, 1103 Paulsen, Ruggeri 140, Schwarzmann, 101-14, Rupestris St. George.	6.6	11.8

Contact for further information

SARDI Water Resources & Irrigation, GPO Box 397, Adelaide 5001. Phone 08 8303 9400.

Note: Tables 1 & 2 are suitable if suction cups are used for measuring salinity. If using a saturated paste extract, multiply the salinity by 2 and then check the results against the values given in Tables 1 & 2.