Best Management Practices for Irrigation Water Salinity and Salt Build-Up in Vineyard Soils

Wine Australia for Australian Wine

The Limestone Coast
Grape & Wine Council Inc.

Government of South Australia
South East Natural Resources Management Board

Cover photo, and top right: Grapevine leaves displaying the impacts of excess root zone salinity. Courtesy of Kerry DeGaris.

Irrigation Water Quality in the Limestone Coast Region

In the Limestone Coast region, irrigation water is obtained from underground aquifers, with the most heavily used being the unconfined Tertiary Limestone Aquifer (TLA). Irrigation water sourced from this aquifer is generally of good quality (salinity less than about 1,200 mg/L as Total Dissolved Solids). However, many irrigators face issues with irrigation water quality that affect productivity or increase the costs of infrastructure and/or labour.

These include:

- High calcium (Ca) and bicarbonate (HCO_3) concentrations that lead to precipitation of calcium (and magnesium) carbonate scale ($CaCO_3$) and blockage of irrigation infrastructure components (e.g. drippers).
- Iron and sulphate bacteria that cause clogging and reduced performance of irrigation infrastructure (e.g. pumps and pipes).
- Elevated salinities in some areas that affect crops and increase soil salinities.

The Limestone Coast Irrigation Water Quality project has been funded by the Limestone Coast Grape and Wine Council (LCGWC), the South East Natural Resources Management Board (SENRMB) and Wine Australia. The first step in the project was an online survey designed to capture information about the extents of irrigation water quality issues in the Limestone Coast region and the approaches that are being used to mitigate these.

The results of this survey are available as a report from the Limestone Coast Grape and Wine Council website (http://limestonecoastwine.com.au). Local information obtained from the survey has been used with a review of national and international literature to develop Best Management Practices (BMPs) for managing irrigation water quality issues in the Limestone Coast region.

The full report on the development of the BMPs is also available from the Limestone Coast Grape and Wine Council website. This brochure provides a user-friendly summary of the background information and the BMPs developed for managing irrigation water salinity and salt build up in vineyard soils.

Some Useful Definitions

The following reference guide provides explanations of some of the terms used in this document in the context in which they are used here. These are not necessarily full definitions.

Aquifer. An underground layer of rock or sediment which holds water and allows water to percolate through.

Groundwater. Water occurring below ground level.

Groundwater salinity. The concentration of dissolved salts in groundwater, usually expressed in parts per million by weight or as milligrams of salts per litre of water (mg/L).

Leaching. Removal of material in solution such as minerals, nutrients and salts through soil.

Unconfined aquifer. Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

Unconfined aquifer Management Area. For the purpose of management and allocation of the groundwater resource, the unconfined aquifer (and the confined aquifer) in the Limestone Coast region has been divided into 'Management Areas'. For the unconfined aquifer, these Management Areas are generally based on hundred subdivisions. Groundwater resource status and condition are often reported by Management Area as it is a useful way to report spatially variable data.

Water table. The level below which the ground is saturated with water.

Well (or bore). An opening in the ground that gives access to underground water.

Irrigation Water Salinity and Salt Build Up in Vineyard Soils

Groundwater is the main source of irrigation water in the Limestone Coast region. Groundwater salinity across the region ranges from very fresh at approximately 600 mg/L total dissolved solids (TDS) to brackish at more than 1,400 mg/L TDS. Application of this water to the soil during irrigation, and subsequent uptake of the water by crops, can cause salt to build up within the root zone (Biswas et al., 2009).

This occurs because plants exclude most salt when they take water from the soil. As water resources become more tightly managed, irrigators seek to achieve higher water use efficiency and now apply water to accurately meet crop needs. These irrigation volumes are often insufficient to flush the salt through the root zone to the water table during an irrigation season, and soil salinity levels are rising in many horticultural areas (Biswas et al., 2009).

Nineteen percent of the respondents to the Limestone Coast Irrigation Water Quality Survey indicated that irrigation water salinity is causing problems with their crops. These were located in the unconfined aquifer Management Areas of Joanna, Padthaway Flats, Waterhouse, Zone 3A, Zone 5A and Bool. However, many more (57%) are already implementing methods to manage irrigation water salinity to prevent impacts on their crops. These methods include using longer irrigations, planting salt tolerant rootstocks, casing-off saline sections of wells, deepening wells or ceasing to use saline wells.

Winter rains can generally be relied upon to flush salt accumulated during the irrigation season from the root zone. However, in some areas, impacts of soil salinity on vine health have recently been observed following a dry winter, suggesting that, in years when winter rainfall is low, it may be necessary to apply extra flushing irrigation volumes during the subsequent growing season to manage root zone salinity.

View of the side of a soil trench dug through the root zone of a vine, showing variations in soil structure that can affect leaching of salt.

Mitigation Strategies

Using Knowledge of Soils, Crop Water Use and Irrigation System to Improve Irrigation Scheduling

Many irrigators in the Limestone Coast region already consider irrigation water salinity in their irrigation scheduling. For those irrigators wanting to base their irrigation scheduling more precisely on crop water needs and also incorporate knowledge of their soil and irrigation system, the Mackillop Farm Management Group has developed an excellent Irrigation Best Practice Glovebox Guide. This provides the basic information and methodologies needed to calculate the irrigation volumes required for different crop and soil types, to facilitate leaching if necessary, and to evaluate the efficiency of irrigation systems. This guide can be found at www.mackillopgroup.com.au.

Monitoring Root Zone Salinity

Management of soil salinity requires regular monitoring. Soil samples can be collected and sent to a laboratory for measurement of soil salinity. This method is useful for checking soil salinity on an annual basis, where salinity has not become a significant problem. However, the technique is time-consuming and costly and not practical for regular monitoring. To manage root-zone salinity issues, irrigators need to accurately measure salt levels in the root-zone and monitor salinity trends over time. There is now a range of effective tools available to assist with this, including suction cups (e.g. the SoluSampler, marketed by Sentek Technologies Australia; www.sentek.com.au) and wetting front detectors (www.fullstop.com.au) (Biswas et al., 2009). It should be noted that suction cups cannot be used when soil tensions are greater than approximately 60 kPa, so these are most useful for measuring soil water salinity at the end of winter or following winter or spring leaching irrigations.

Winter Leaching

Leaching of salts from the root-zone continues to be the most effective technique for root-zone salinity management (Biswas et al., 2009). However, the leaching process is complex and is not always completely effective due to the presence of natural pathways through which water moves preferentially. This causes salt to build up in other parts of the soil. The build-up of salt in soil can also affect soil structure. Efficient leaching of soil therefore requires an understanding of soil structure. Winter leaching to complement rainfall is the most practical way to reduce root-zone salinity. The soil is wet and any potential preferred pathways may have "closed up". Also, water applied during winter undergoes less evaporation and transpiration.

Enhanced Leaching in Vineyards by Mounding in the Mid-Row

One of the solutions to vineyard root zone salinity problems that has been investigated extensively is mounding of soil in the mid-row and covering it with plastic to focus winter recharge in the vine row (Stevens et al., 2012). This was found to reduce soil salinity by 38% and the concentrations of sodium and chloride in juice by 35%. It was also found that, where soils had become saline and sodic due to below average winter rainfall, subsequent above average winter rainfall events were able to reclaim these soils.

Mid-row mounding and lining with black plastic to focus recharge towards vine roots. Source: Stevens et al. (2012).

Recommended Best Management Practices

Where there is a potential for crop issues caused by irrigation water salinity (i.e. where irrigation water salinity is greater than about 1,200 mg/L), but a problem has not yet been identified, irrigators should be proactive and:

1. Monitor irrigation water salinity to detect changes over time.
2. Get to know the characteristics of the soils on their properties and familiarize themselves with the factors influencing their irrigation system efficiencies.
3. Measure root zone salinity at the end of each winter at locations that cover the ranges of soil and crop types on the property and identify any changes.
4. Monitor foliage for visual symptoms of salt damage; test the chemical composition of leaf/fruit tissue on a regular basis.

Biswas et al. (2009) recommend the following protocol for managing root-zone salinity, where the problem has been identified:

5. Measure root-zone salinity two to three days after at least 15-20 mm of rainfall in one week. Check this measured value against the crop threshold, or a target threshold that is acceptable (e.g. see Biswas et al., 2009 for examples of crop thresholds for maximum production and for reduced yields). In measuring root zone salinity, disregard any spikes that occur soon after fertilizers are applied.
6. Apply one or several small leaching irrigations, and re-check root-zone salinity. The aim is to reduce root-zone salinity to (or slightly below) the threshold by the beginning of each irrigation season.
7. Record all soil salinities measured and leaching volumes applied to identify the optimum leaching volumes for your crop and soil over time.
8. Where there is a shallow or saline water table, install sub-surface drainage below the water-table to remove the saline water.
9. Apply a surface cover (e.g. mulch or perennial grass) of at least 30% to reduce salt accumulation by reducing evaporation.
10. Take care of soil structure by building up soil organic matter. This will improve the efficiency of leaching irrigations.

Further Information and References

Biswas, T., Bourne, J., Schrale, G. and McCarthy, M. (2009). Salinity Management Practice Guidelines. Managing root-zone salinity for irrigated horticultural crops in winter rainfall zones of Australia. Sustainable Irrigation Management Update report by the National Program for Sustainable Irrigation, Land and Water Australia, Canberra, Australia. Internet address: http://lwa.gov.au/products/pn22225.

Stevens, R.M, Pitt, T.R and Dyson, C. (2012). Managing soil salinity in groundwater irrigated vineyards. Final report to National Program for Sustainable Irrigation by the South Australian Research and Development Institute. Internet address:

http://www.naturalresources.sa.gov.au/files/sharedassets/south-east/water/irrigation/managing-soil-salinity-in-groundwater-irrigated-vineyards-gen.pdf

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