Chapter B7. Managing saline soils

PURPOSE OF THIS CHAPTER

To outline the management of saline soils

CHAPTER CONTENTS

- causes and signs of salinity
- management strategies

ASSOCIATED CHAPTERS

- B10 ‘Does my soil need fertiliser?’

COST AND EXTENT OF SALINITY

About 33% of all irrigated lands world-wide are affected by varying degrees of salinity.

In New South Wales, waterlogging and salinity cost irrigated agriculture an estimated $40 million a year.

The key horticultural areas affected in New South Wales are the MIA, Murray Valley, Sunraysia Irrigation Area, Hunter Valley and small areas in the Sydney Basin and southern slopes around Young. Salinity is also an emerging problem in the Gwydir and Namoi Valleys

WHAT IS SALINITY?

Salinity is the amount of salt in the soil or water. The dominant salt in most saline soil is common salt—sodium chloride (NaCl). Varying amounts of calcium, magnesium and potassium chlorides and sodium sulfates can also occur.

It is important to know the level of salinity. This determines:

- the types of plants that will grow in the soil, and their yield potential
- the characteristics of a soil
- the quality of water for irrigation, domestic, industrial and stock use
- the extent of the problem.

HOW IS SALINITY CAUSED?

Natural salinity

Salt is a constituent of nearly everything in nature. Sodium is found in nearly all rocks and is abundant in soil minerals. Coastal breezes carrying salt can deposit significant amounts, while natural rainfall contains small but measurable quantities of sodium chloride. Natural rainfall is, however, usually considered beneficial in flushing salt from the root zone.

Natural salt deposits occur where there are groundwater fluctuations, where salty water is discharged, or where topsoil is removed to reveal saline scalds.

Groundwater fluctuations

When the watertable (the top of the ground water) rises due to fluctuations in rainfall, salt is dissolved from the deeper layers and can be deposited in the root zone when the water evaporates from the surface. This tends to be a periodic occurrence, but over time it causes salt accumulation.

Salt lakes

Saline ground water has the potential to build up enormous amounts of pressure, particularly if it is confined within a layer of coarse sediment or porous rock, called an aquifer. This pressure is released at an aquifer outlet or discharge area (where the aquifer meets the soil surface), resulting in the formation of a salt lake.

Scalds

Saline scalds develop when topsoil is removed to expose a subsoil that is high in salt. The saline subsoil is often a result of salt blown from the dry beds of salt lakes. The saline topsoil is also blown from adjacent areas and deposited over long periods of time.

Natural rainfall flushes the salt through the sandy topsoil to the less permeable subsoil, where it accumulates in large amounts. When wind erosion exposes the subsoil a scald is formed. This frequently occurs in western areas of the State.

Induced salinity

In many cases human intervention is responsible for salinity problems, in both irrigation and dryland areas.

Irrigation

Farming methods that result in excessive amounts of irrigation water percolating through the soil profile have been responsible for increasing the height of the watertable.

When large quantities of water are applied to a soil that is quite permeable, or water is left on less permeable soils for long periods of time, the watertable will rise rapidly.

It may bring with it large amounts of dissolved salts. When the water is evaporated from the surface, the dissolved salt will remain behind in the root zone.

Dryland salinity

Farming practices throughout New South Wales have involved the removal of large numbers of trees that previously pumped water from the soil to the atmosphere by transpiration.

Pastures and crops that have replaced tree cover pump much less ground water because of their shallow roots and smaller leaf area. Watertables therefore rise with rainfall, bringing dissolved salt nearer the surface.

In some situations, this ground water moves through aquifers and increases the height of watertables in nearby irrigation areas. Alternatively, watertable rises under irrigation areas may affect nearby dryland areas. These are difficult to reclaim, as irrigation cannot be used to wash salt down from the soil surface.

How a rising watertable affects salinity

The watertable will rise when the amount of water entering the soil profile exceeds that leaving the soil profile.

If rainfall or irrigation percolates through the soil in excessive amounts and there is either an impermeable layer or an existing high groundwater level, the watertable will rise. When the watertable is about two metres from the soil surface, ground water can be brought to the surface by capillary rise. Water is then evaporated from the soil surface, leaving dissolved salts behind in the root zone.

Capillary rise is the movement of water upwards from the watertable (the top of the ground water) into the unsaturated soil above. It can be likened to a dry sponge (the unsaturated soil) being placed on top of a wet surface (the watertable). The sponge sucking up water is similar to capillary rise in soil.

Capillary rise occurs regardless of the depth of a watertable. If the watertable is below two metres, however, capillary rise does not reach the root zone of most agricultural plants. Therefore, one aim of irrigation, drainage and land management should be to keep the watertable well below two metres depth from the surface and so keep salty ground water well away from plant roots.

The relationship between salinity and waterlogging

Salinity has been defined as the amount of salt in soil. Waterlogging is the saturation of soil with water for a period of at least one day or more.

Waterlogging should not be confused with salinity. Waterlogging problems can exist on their own without soil salinity. When a soil is saturated with water, for instance, plant roots are unable to breathe because oxygen becomes unavailable. However, waterlogging can be a contributing factor to rising watertables, thus increasing the threat of salinity.

RECOGNISING PROBLEM AREAS

Sometimes it is quite difficult to recognise salinity problems because:

- plants often respond to excess salt the same way they would to other soil problems such as water stress
- salinity is often associated with waterlogging
- the yield of the plant may decline by 30% before signs become evident
- where there is no evidence of salt on the soil surface and plants are not showing obvious characteristic signs of salt damage, land owners must rely on maps of the region or specific soil tests.

General signs

- Leaves appear smaller and darker than normal.
- Marginal and tip burning of leaves occurs, followed by yellowing and bronzing.
- Germination is slow.

- Plants grow poorly.
- Salt-tolerant species predominate.
- Vegetation dies.
- A white crust forms over bare ground.

In crops and pastures

- Legumes are more susceptible to high salinity than grasses, so grass-dominant pastures may be an indication of soil salinity.
- Overall yield will decline in saline areas.
- Establishment is often slow, leaving plants more susceptible to damage from disease and water stress.

MANAGEMENT STRATEGIES

Leaching

Leaching excess salts and maintaining a favourable salt balance remains the best strategy to prevent detrimental salt accumulation in the soil profile. This is achieved by supplying enough water to leach salts below the root zone but not into ground water reserves.

Drainage

A prerequisite to using leaching as a management tool is good internal and external drainage. Poor internal soil drainage caused by surface crusting, hardpans and sodic conditions is often managed by tillage and soil amendments.

Regular deep ripping is recommended in these situations. When sodic conditions exist an aggressive soil amendment program is required, for example, using gypsum.

Surface drainage is important, particularly with furrow irrigation. Laser levelling is a standard recommendation, and growers should be aware of crop water requirements to avoid over-irrigation.

The increasing use of tile drains in horticultural plantings (and mole drains in vegetable production) is helping to improve internal drainage.

A thorough soil survey before planting new areas is strongly recommended.

The irrigation method

The irrigation method and volume of water applied have a pronounced influence on salt accumulation and distribution. Flood irrigation and an appropriate leaching fraction generally move salts below the root zone. Similar results can be obtained with a properly managed sprinkler irrigation system.

With furrow and pressurised irrigation, soluble salts in the soil move with the wetting front, concentrating at its termination or at its convergence with another wetting front. In drip-irrigated plots, water moves away from the emitter and salts concentrate where the water evaporates. In furrow-irrigated plots, water movement is from the furrow into the bed via capillary flow. When adjacent furrows are irrigated, salts concentrate in the centre of the intervening bed. Manipulating bed shape and planting arrangement are strategies often used to avoid salt damage in furrow-irrigated row crops. Because drip irrigation maintains more constant favourable conditions of soil moisture, plants tolerate higher levels of salinity than with furrow irrigation.

Fertiliser management

Many fertilisers contain soluble salts in high concentrations. Therefore, the nutrient source, rate, timing and placement are important considerations in the production of horticultural crops. Salt indices for most commercial fertiliser products have been reported. For example, KCl has a salt index 205 times that of K_2SO_4. Generally, band application of fertilisers with high salt indices near seedlings should be avoided.

The salt content of other things added to the soil, such as gypsum and manures, also should be considered. Applying gypsum is a useful management practice for precluding sodium accumulation on the soil's exchange complex, maintaining soil structure and improving water infiltration.

For salt-sensitive crops such as lettuce, apply gypsum well before sowing so that soluble salts released during dissolution do not negatively affect production.

Soil amendments and water treatments

Soil amendments and water treatments often offer a practical and economical means for managing many problems common to saline and sodic soils. Soil applications of amendments are used for initial reclamation and long-term maintenance of soil quality. In general, water applications are intended to alter the chemistry of irrigation water such that no further degradation in soil quality will occur. Rates of amendments used for soil application are typically large and primarily based on economics. For water treatments, rates of amendments are typically much smaller and are nearly always based on solubilities.

Amendments such as gypsum and elemental S have been used for years. Gypsum is primarily used on Na-affected soils as a source of Ca^{++} ions to displace Na^+ ions, which tend to disperse soil particles and restrict water infiltration. The resulting displaced Na^+ ions are leached readily from the soil profile. Gypsum is a neutral salt that does not directly reduce pH. However, it can indirectly lower the pH of sodic soils by reducing the hydrolysis reactions associated with Na^+ ions on the exchange complex.

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See Chapter D5 for more information on sodic soil management.

CONCLUSION

Many economically important horticultural crops are sensitive to soil and water salinity (see Table B7–1) and to the deterioration of soil physical properties associated with Na in soil and irrigation water. Therefore, soil chemical and physical properties, crop tolerance, water quality, fertilisation and irrigation methods are important considerations for the production of horticultural crops if we are to avoid the extreme salinity seen in some parts of the world (Figure B7–1).

Table B7–1. The relative salt tolerance of a range of vegetables, expressed in terms of soil salinity and in order of sensitivity at 90% yield.

Crop	Salinity threshold EC_{se} (dS/m)	Soil salinity EC_{se} at 90% yield (dS/m)
Pea	1.0	–
Bean	1.0	1.5
Carrot	1.0	1.7
Onion	1.2	1.8
Lettuce	1.3	2.1
Pepper	1.5	2.2
Corn (grain sweet)	1.7	2.5
Potato	1.7	2.5
Tomato	2.3	2.8
Cabbage	1.8	2.8
Spinach	2.0	–
Watermelon	–	2.0
Cantaloupe (rockmelon)	2.2	–
Cucumber	2.5	3.3
Broad bean	2.3	–
Celery	1.8	3.1
Broccoli	2.8	3.9
Squash	4.7	5.8
Zucchini	4.7	5.8
Garden beet	4.0	5.1

References:

Landscape, Soil and Water Salinity, Brisbane Workshop May 1987.
Journal of Irrigation and Drainage Division, Proceedings of American Society of Civil Engineers 103: 115–130.

Notes:

1. Salinity threshold EC_{se} (dS/m) is a measure of the electrical conductivity of a soil saturation extract at the point which soil salinity begins to decrease crop yield.
2. Soil salinity EC_{se} (dS/m) at 90% yield is a measure of the electrical conductivity of a soil saturation extract at which salinity reduces maximum crop yield by 10%.

Figure B7–1.

Extreme salinity in the Aral Valley irrigation district, Russia. This occurred as a result of poor irrigation practices and the farmers' blasé attitude to the impending degradation. (Don Blackmore)