Chapter D5. Sodic soil management

PURPOSE OF THIS CHAPTER

To describe how to manage sodic soils

CHAPTER CONTENTS

- problems caused by sodicity
- on-farm management of sodicity

ASSOCIATED CHAPTERS

- A3 ‘Features of soil’
- B6 ‘Does my soil need gypsum?’
- B8 ‘Dispersion’
- D4 ‘Slaking and dispersion’
- E1 ‘Key checks for productive irrigated soils’

WHAT IS SODICITY?

Sodicity is a term given to the amount of sodium held in a soil. Sodium is a cation (positive ion) that is held loosely on clay particles in soil. It is one of many types of cations that are bound to clay particles. Other types bound to clay particles include calcium, magnesium, potassium and hydrogen. When sodium makes up more than about 5% of all cations bound to clay particles, structural problems begin to occur, and the soil is said to be **sodic**. The amount of sodium as a proportion of all cations in a soil is the main measure of sodicity used, and is termed the exchangeable sodium percentage (ESP). This can be calculated from chemical soil tests.

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See Chapter D3 for more information on chemical soil tests.

Salinity is a measure of the concentration of the **soluble** salts contained in the soil. These salts are free to move in the soil water and can be readily taken up by plants. These salts, which move freely in the soil solution, are made up of positive and negative ions (cations and anions). At any time, many cations are bound loosely to the surfaces of clay particles and **are not** free to move in the soil solution.

Cations in solution will often swap with those bound to clay particles. Therefore, if saline water with a high proportion of sodium is applied to a soil, the proportion of sodium bound to the clay particles may increase due to swapping of sodium in solution on to the clay particles. Similarly, if a solution high in calcium (a type of cation) is applied to a soil, the proportion of calcium bound to clay particles may increase. The process of cations swapping from solution to be bound to clay surfaces and vice versa is called cation exchange.

WHY IS SODICITY A PROBLEM?

High sodicity causes clay to swell excessively when wet. The clay particles move so far apart that they separate (disperse). This weakens the aggregates in the soil, causing structural collapse and closing-off of soil pores. For this reason water and air movement through sodic soils is severely restricted.

In vegetable crops, sodic layers or horizons in the soil may prevent adequate water penetration when during irrigation, making the water storage low. Additionally, waterlogging is common in sodic soil, since swelling and dispersion closes off pores, reducing the internal drainage of the soil.

Sodicity of the surface soil is likely to cause dispersion of surface aggregates, resulting in surface crusts.

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See Chapter D4 for a test for dispersion.

Self-mulching clays

These soils are well structured and non-sodic at the surface. There is generally more calcium rather than sodium attached to the clay particles; this is why self-mulching clays are well structured. The deeper subsoil of these soils can be sodic, so waterlogging is possible.

Non-self-mulching clays

These soils are sodic at or near the surface; the sodicity increases with the depth. Therefore, these soils are likely to have water storage and waterlogging problems. Establishment of crops is often difficult due to crusting and poor tilth.

Red brown earths

The topsoils of red brown earths are usually non-sodic, and relatively low in clay content. The subsoils are generally sodic and higher in clay content. This means that water penetration of the subsoil is low. Therefore a ‘perched’ watertable can form above the subsoils of red brown earths. Since water penetration of the topsoil is generally good, the deeper the topsoil the more water can be stored at each irrigation.

Transitional red brown earths

The topsoils of transitional red brown earths can sometimes be sodic. This will cause crop establishment problems such as crusting. The subsoils are generally sodic and will therefore swell and restrict air and water movement. If the topsoil is non-sodic, water will move though the topsoil relatively rapidly, but only very slowly into the subsoil. Water storage may be poor if the topsoils are shallow. In some soils of the Murrumbidgee Valley and at Colleambally, the subsoils are non-sodic clay, and appear to be well structured when they are exposed by landforming.

Sandhill soils

The topsoils of sandhill soils are very low in clay content and non-sodic. The subsoils may be sodic, and can cause plant growth problems if the subsoil begins within the root zone of the crop being considered.

ON-FARM MANAGEMENT OF SODIC SOILS

Determining whether your soil needs treatment

The first step in determining whether a soil needs treatment for sodicity is to determine how sodic it is. A dispersion test is described in Chapter D4. If this test gives a dispersion score of 6 to 16, then the soil may be gypsum responsive. In this situation do a soil test to calculate the exchangeable sodium percentage (ESP). (See Chapter D3.) Table D5-1 is a guide to the gypsum response of surface soil.

Table D5–1. Gypsum application rate with respect to soil ESP

Exchangeable sodium percentage (ESP) of cut area	Gypsum application rate t/ha
Greater than 5, less than 10	2–5 t/ha
Greater than 10	5 t/ha

Using gypsum

Gypsum contains calcium sulfate. Calcium sulfate is a salt, but unlike sodium chloride (the main component of salt in saline watertables) it is not toxic to plants. Gypsum will help to reduce swelling and dispersion of the soil through two mechanisms. These are:

1. Gypsum slightly increases the salinity of the soil solution, and hence reduces swelling. The same effect can be seen when using saline bore water, but this often contains high levels of sodium and chlorine that are toxic to plants. Gypsum will slightly increase salinity without any detrimental effect on plants.
2. Calcium from the gypsum will swap with the sodium that is held on the clay surfaces. This reduces the sodicity of the soil and is called cation exchange.

Gypsum can have its most beneficial effect at sowing time. It can provide better soil tilth, and can reduce crusting in sodic surface soils, hence improving establishment. If you use gypsum where the surface soil is sodic, time the application so that rain or irrigation does not leach the gypsum from the surface soil by sowing time.

Cultivation practices on sodic soils should be aimed at preserving soil organic matter in the surface soil. This is usually achieved by less aggressive, reduced tillage. Non-inversion tillage is useful for leaving the more sodic subsoil at depth.

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See Chapter D7 for more information regarding tillage practices.

In many soils of the Murray and Murrumbidgee Valleys (especially red brown earths), the topsoil is non-sodic and of reasonable depth (10 to 40 cm). However, these soils will often have sodic subsoils. Gypsum applications to these soils will have little effect on the topsoil but will increase the structure, aeration and permeability of the subsoils. This is likely to increase water storage and reduce waterlogging.

The depth of the non-sodic topsoil is an important consideration in the likely response of a sodic subsoil to gypsum improvement. Since a non-sodic topsoil is usually a better environment for plant growth anyway than a sodic topsoil, responses to gypsum will be low or unlikely when there is good depth of topsoil—the existing soil structure will allow optimum plant growth.

As a rough guide, if the non-sodic topsoil is greater than 15 to 20 cm deep, then a gypsum response may be unlikely. Remember, it may take a few months before gypsum leaches into the subsoil and begins to take effect.

Gypsum test strips

It is highly recommended that you do test strips before applying large amounts of gypsum. You may want to try some test strips at various rates (2.5 t/ha and 5 t/ha, for example). If a whole paddock is being treated, leave an untreated strip to show whether gypsum has had an effect. If the treated soil responds to gypsum, you will notice increased soil friability, less power needed for tillage, improved infiltration, less waterlogging, and better seedling emergence.

Lime application to sodic soils

Lime (calcium carbonate), like gypsum, is a compound containing calcium. Therefore it can contribute to reducing the effects of sodicity. However, lime is relatively insoluble at a soil pH ($CaCl_2$) above 5. In most soils of the Murray and Murrumbidgee Valleys the pH ($CaCl_2$) is above 5, so lime is of little benefit. If the pH is below 5, lime will help to reduce both acidity and sodicity problems. A mixture of lime and gypsum may be a good option on sodic soils with a pH ($CaCl_2$) in the 5 to 6.5 range, to provide a more long-lasting effect than gypsum only. Again, test strips are strongly recommended.

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See Chapter D7 for more information about cultivation practices.

Cultivating sodic soils

Sodic soils are more prone to structural degradation than non-sodic soils. For this reason they must be cultivated minimally and carefully. Excessive cultivation of these soils will cause major soil structure problems. In vegetable soils this may be evident as crusting, hardsetting and poor water penetration.

Deep ripping and gypsum

Deep ripping has shown to benefit water penetration, aeration and plant growth on poorly structured soils. However, the benefits of ripping are short lived, especially on sodic soils.

One technique that has shown benefits on sodic soils is the application of high rates of gypsum (5 to 10 t/ha) before deep tillage. This technique is even more successful when gypsum is concentrated into the rip lines, by being applied either directly into them or in a band before each ripping tine. This method concentrates the gypsum, allowing it to stabilise the rip lines against slaking and dispersion for longer periods of time.

Even when gypsum is applied at heavy rates it will leach out of the soil. Therefore ripping and gypsum will need to done every 2 to 3 years if the effect is to be maintained.

Remember to use non-inversion tillage for this operation.

Using saline irrigation water

Many farmers are now using bore water to irrigate crops and pastures. However, be careful with this as you may experience problems, including:

- a build-up in soil salinity and therefore a decrease in crop production
- an increase in soil salinity in districts such as the Murrumbidgee Irrigation Area, where much of the ground water is sodic.

As Figure D5–1 indicates, a sodic soil can be well structured if the soil is saline enough to prevent dispersion. This is why saline water or gypsum (a calcium salt) improves soil structure on sodic soils. However, avoid using saline water for irrigation, since:

- soil sodicity is likely to increase. If the sodicity increases and soluble salts are leached out (washed out) of the soil by fresh water, the soil will become poorly structured.
- soil salinity will increase.

However, careful irrigation does have its place (Figure D5–2).

Figure D5–1. The relationship between soil salinity, soil sodicity and soil structure

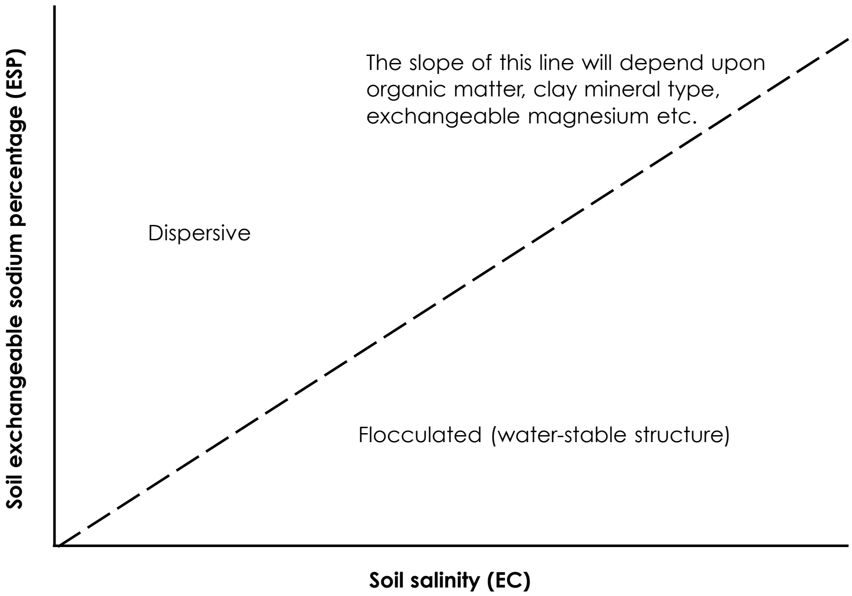

Figure D5–2.

Delegates at the Horticulture Downunder Conference, Barooga, inspecting trickle-irrigated tomato seedlings. Trickle irrigation is an important tool for overcoming soil salinity problems. (Bernie McMullen)