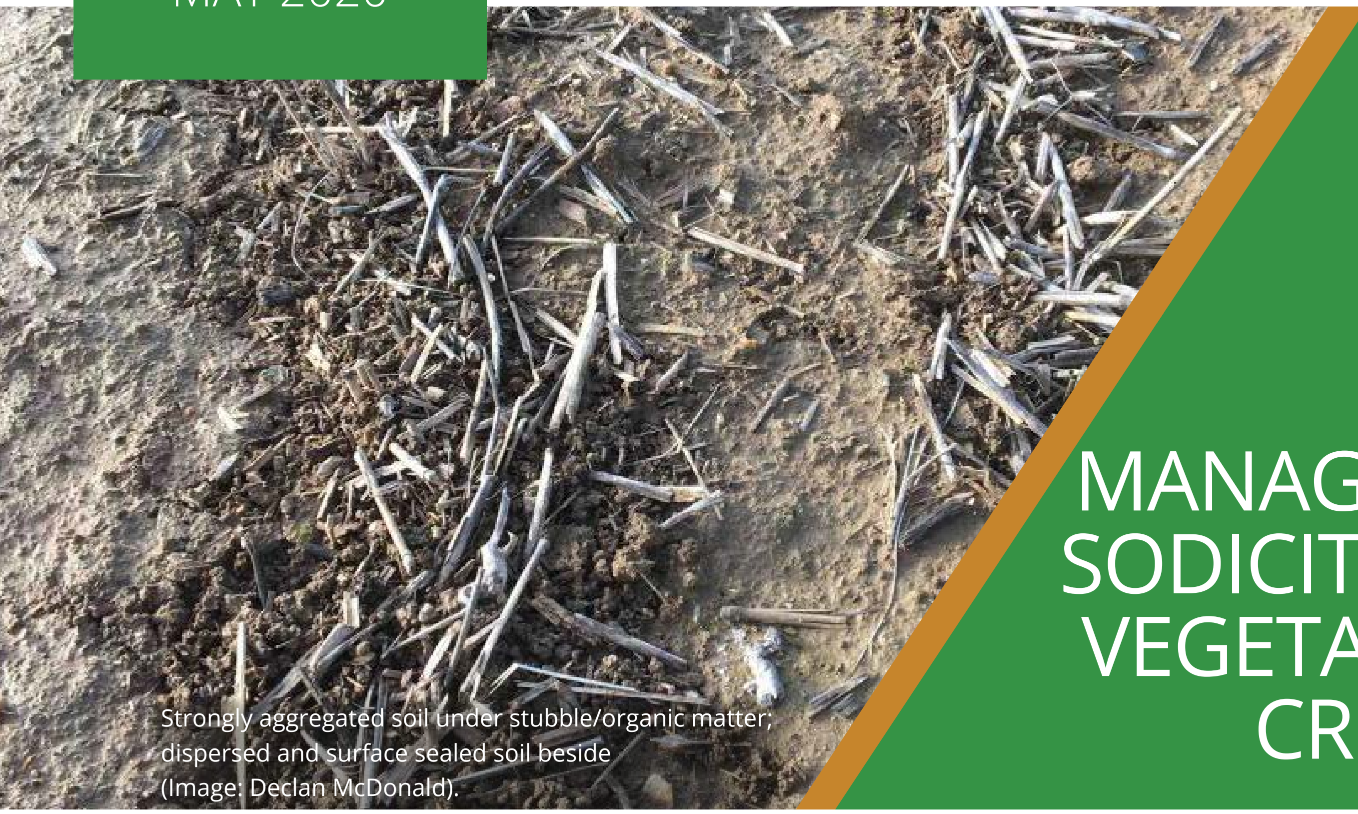
MAY 2020

MANAGING SODICITY IN VEGETABLE CROPS



Strongly aggregated soil under stubble/organic matter; dispersed and surface sealed soil beside (Image: Declan McDonald).

KEY MESSAGES

✔ Sodicity is different to salinity.

- Sodic soils – **sodium (Na) occupies more than 6% of cation exchange sites in the soil; sodic soils have an Exchangeable Sodium Percentage (ESP) > 6%.**
- Saline soils - see the Soil Wealth ICP factsheet - Managing Salinity in Vegetable Crops.

✔ Sodic soils are sticky when wet and crusty, hard setting when drying, resulting in poor soil structure; this decreases:

- Water infiltration and drainage
- Water holding capacity
- Airflow in the soil
- Root penetration and thus crop growth.

✔ Many sodic soils also contain high levels of magnesium (Mg). This exacerbates the negative effect Na has on soil structure and competition with cations such as Ca and K.

✔ Management options for sodic soils:

- apply good quality gypsum that is low in sodium and other salts
- apply good quality gypsum and lime (if soil is acidic)
- apply potassium (K) fertiliser to soil as a foliar application
- use fertilisers containing high levels of soluble calcium
- avoid using recycled water that is high in Na
- maintain or increase soil organic matter.

✔ Minimise cultivation of sodic soils and avoid disturbing sub-soils that are sodic.

✔ The higher the electric conductivity (EC) of a sodic soil, the lower the negative effect of Na on, aggregate disintegration (dispersiveness) and thus soil structure .

- The Electrochemical Stability Index (ESI) from soil tests provides information on the potential effect sodium will have on soil structure because the saltiness of the soil solution counteracts the 'slumping' of aggregates. ESI assesses the relationship between ESP and EC.

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HOW TO MANAGE SODICITY

First, determine if your soil needs treatment (see Appendix).

1. Check whether the topsoil and or subsoil are dispersive i.e. aggregates disintegrate easily or slump when wet. This can be done via 'Slakes', the first soil aggregate stability mobile app or a traditional dispersion test; methods can be found via an internet search.
2. Determine the top-soil pH and sub-soil pH. This can be done via a laboratory test, a handheld pH meter (calibrated) or a colour indicator test.

Gypsum

Applying gypsum if the soil is dispersive and the pH is above 7. Apply gypsum plus lime, if the soil is sodic and acidic (pH is below 7). The Ca ions will displace some of the Na ions on the soil exchange sites.

Consider applying different rates of Gypsum test strips in the paddock before applying large amounts and/or to a large area.

Table 1 provides general guidance only. The need for and effectiveness of gypsum are influenced by:

- Gypsum quality (esp. contamination with sodium)
- Soil mineral composition
- Soil organic matter level

Generally, the higher the percentage of clay particles and the lower the amount of organic matter in the soil, the more gypsum is required. Gypsum with high levels of sodium or other contaminants should not be used.

Consider deep ripping and gypsum, depending on subsoil quality

Deep ripping has short lived benefits for sodic soils. However, application of high rates of gypsum (5 to 10 t/ha) prior to deep ripping, particularly if it is concentrated into the rip lines, has shown benefits. This allows the rip lines to stabilise against slaking and dispersion for longer periods of time. Gypsum will leach out of the soil, even at these high rates of application, and so will need to be reapplied with deep ripping every two to three years, if testing shows that the soil is slumping again.

Minimise cultivation

Minimise cultivation because sodic soils are more prone to degradation and water erosion.

If cultivation is necessary, using non-inversion tillage is particularly important for dispersive subsoils. Strip tillage should be used if possible.

Table 1 A guide to the rate of gypsum application required according to the degree of dispersion (aggregate disintegration), exchangeable sodium percentage (ESP, sodicity) and pH of the soil (from WA DPIRD)

Dispersive behaviour or sodicity rating	Exchangeable sodium percentage (ESP %)	Gypsum application rate on neutral to acid soils (t/ha)	Gypsum application rate on alkaline soils (t/ha)
Slight	6–10	0–1.5	1.0–2.5
Moderate	10–15	2.5	5.0
Severe	>15	5.0	5.0

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Manage irrigation water quality

Management options will depend on whether the soil is saline-sodic or non-saline sodic.

- Non-saline sodic soils are usually dispersive if fresh water is applied. Switching from saline water to fresh (low salinity) water on a sodic soil, can cause the soil to disperse i.e. the soil structure disintegrates. In this situation, progressively increase the proportion of low salinity water, if possible.
- Saline-sodic clay soils are usually less dispersive than non-saline sodic soils. Fresh water can be used without causing any or much dispersion.

Organic matter

Maintain or increase organic matter (see Figure 2) e.g. with cover crops and soil amendments. Ensure that soil amendments are not adding sodium to the soil.

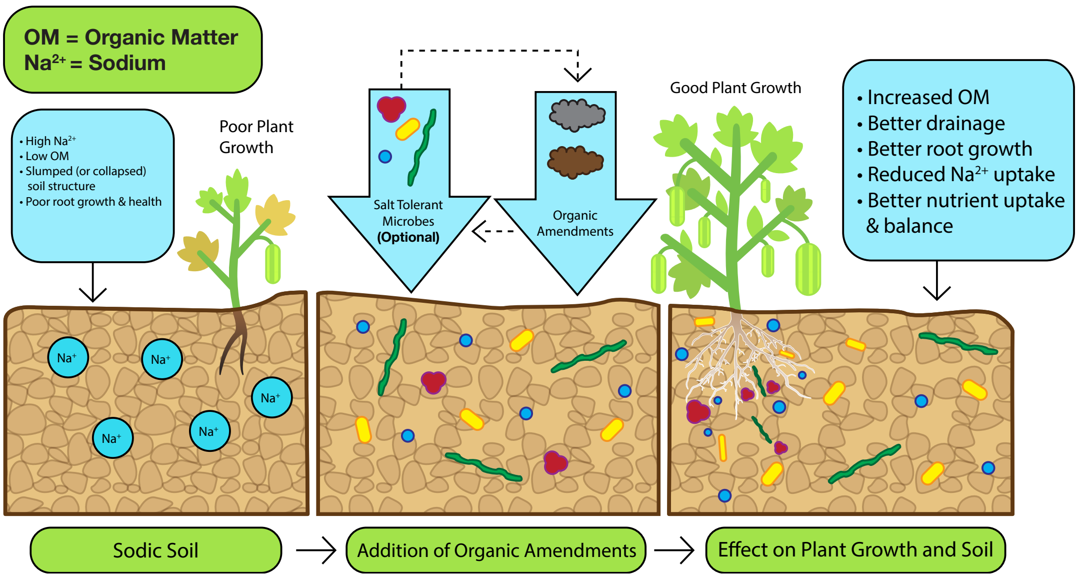
WHY IS SODICITY BAD?

Sodic soils have poor structure, they 'slump', i.e. aggregates disintegrate causing the soil to lose structure. Sodic soils are hard setting when dry and sticky when wet. They are also prone to water erosion. The term 'dispersion' or 'dispersive soil' describes this condition.

Effects on vegetable crops:

- Seedling emergence, crop establishment and growth can be affected due to hard setting and crusting of soil or frequent waterlogging due to poor drainage
- Root growth is restricted due to soil being denser, containing little air
- If the exchangeable Na is large, less Ca, K and Mg is available in the soil and taken up by plants; some of these cations, especially K are replaced by Na in plants
- Sodic soil often has a high, alkaline pH, thus the availability of trace elements, e.g. P, Fe, Mn and Zn, is likely to be reduced.

Figure 2 Soil organic matter and sodic soils



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Dispersive soil

"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."

NSW DPI, SOILpak for Vegetable Growers Chapter D5 - Sodic Soil Management

SODICITY EXPLAINED

Some soils are naturally sodic. The term sodicity refers to a large proportion of sodium ions in the soil relative to other cations. Cations are held in a soil on negatively charged exchange sites of clay minerals and organic matter. Sodium (Na) is a cation just like calcium (Ca), magnesium (Mg), potassium (K) hydrogen (H), aluminium (Al) and trace metals. If sodium is in the soil in large amounts, it can replace other cations on exchange sites. Recycled water can contain Na. Therefore, monitor irrigation water and also soil if using recycled water, shandy with fresh water, if recycled water quality is poor.

A measure of the number of available cations a soil can hold is the 'cation exchange capacity' (CEC). The proportion of Na of the CEC is the 'Exchangeable Sodium Percentage' or ESP.

Soil sodicity starts to have a negative influence on soil structure and crop growth when more than 6% of the soil cations are Na (ESP > 6%).

Due to the soil structure effects, i.e. slumping, root growth and soil life are restricted by low oxygen availability in wet, dispersed soil and high penetration resistance when the soil is dry. Nutrient availability and uptake are affected due to the interaction between cations, restricted root systems and low microbial activity. Sodium becomes toxic to plants and soil life in sodic soils.

WHAT IS THE DIFFERENCE BETWEEN SODICITY AND SALINITY?

Salinity refers to the 'saltiness' of soil or water. The higher the concentration of water-soluble salts in the soil solution or in water, the higher the salinity.

Different to salinity, Cl is not involved in sodicity. Salinity is measured via electrical conductivity (EC) and also chloride content. Draining of saline soils can result in Cl being removed and sodium being left behind, turning the soil from saline to sodic.

Applying leaching irrigation (with fresh water with low or no salinity) to flush salts from the rootzone, may also lead to sodicity. In heavier soils, Cl may leach, but too much Na may stay behind in the rootzone as it 'binds' to clay particles. This can lead to sodicity issues. Ensure that drainage water can leave the paddock via drainage systems in the landscape.

HOW CAN SODICITY BE IDENTIFIED?

Sodicity can be identified in a variety of ways, including:

- **visual identification**, e.g. soil slumping/dispersion, milky-coloured water ponding, boggy when wet, hard setting when dry, surface crusting when dry, susceptible to water erosion (including tunnel erosion).
- **plant symptoms** (e.g. leaf necrosis)
- **field tests** for soil dispersion e.g. suspend a small piece of soil in distilled water and look for cloudiness (Figure 3).
- **soil test results** i.e. look for the ESP%
- **plant tests** show high Na uptake (ESP% >6) and reduced K uptake.

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SLAKING & DISPERSION

All clays swell on wetting. The process of swelling causes particles to mechanically break off from the aggregate due to trapped air bursting out (**slaking**). - This is a different observation to **dispersion** where the clay disperses to form a milky cloud around the aggregate and is caused by excessive sodium ions interfering in the soil structure .

Slaking can occur in non-sodic soils. Organic matter reduces slaking by binding mineral particles and by slowing the rate of wetting.

SOIL SLAKING & DISPERSION TEST

Use the information below or the NSW DPI Slaking and Dispersion resource.

Take separate samples from the topsoil and the subsoil and test them separately. Use an aggregate of soil of about 5 mm in diameter. Air dry the soil for a couple of days. Place the soil aggregate into a shallow dish of rain water or distilled water.

In the first few minutes observe for **slaking**.

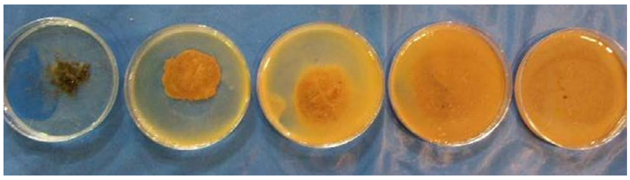
Leave the samples undisturbed for 20 hours and then score them for **dispersion** (Table 2 and Figure 3).

Sometimes soils can become dispersive after a lot of cultivation.

Table 2 Soil dispersion test descriptions

Description	Soil dispersion rating	Soil type
No dispersion	0	Non-dispersive
Soil partly disperses	1-2	Moderately dispersive
Soil completely disperses	3-4	Highly dispersive

Figure 3 Soil dispersion test - scoring (from Conrangamite CMA 'Brown Book')



0 No sodicity | 1 | 2 | 3 | 4 High sodic / low salt

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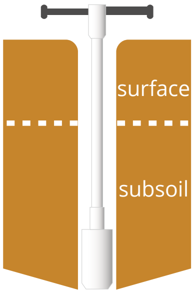
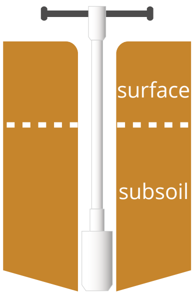
APPENDIX

Figure 1 Controlling the problem - Examples of commonly found soil profiles and what to do (image originally in Australian Soil Fertility Manual, and Managing sodic, acidic and saline soils)

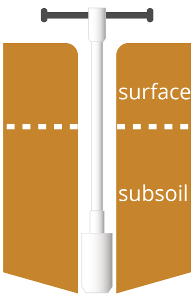
is your soil...



surface	acid	acid	acid	neutral
subsoil	acid	sodic (alkaline)	saline	acid
You need to....	• add lime	• add lime first • then add gypsum	• add lime • improve drainage • adjust nutrition	• add lime



surface	neutral	neutral	alkaline	sodic
subsoil	sodic (alkaline)	saline	sodic (alkaline)	acid
You need to....	• add gypsum	• adjust nutrition program	• adjust nutrition program • add gypsum	• add gypsum



surface	sodic	saline	saline & sodic	highly sodic
subsoil	saline	with any other combination	saline & sodic (alkaline)	highly sodic (alkaline)
You need to....	• add gypsum	• see Managing Salinity in Vegetable Crops factsheet	• manage salinity • try test areas of gypsum	• add gypsum

Adapted from 'Managing Sodic, Acid and Saline Soils prt 3', P. Rengasamy and J. Bourne (1997) (available Agriculture Victoria website)