Sodium in Irrigation Water

TS15

Part 1: Effects on Soil and Plant Growth and Development

Irrigating with water sources high in sodium is a concern as soil structure and plant growth and development can be affected. The condition is called sodicity.

Soil Structure

Sodicity changes the size and shape of the soil crumbs therefore their structural arrangement in soil. This leads to rearrangement of the pore spaces and loss of larger pores responsible for good aeration and drainage. Sodium affected soil is hard-setting, more likely to form thick crusts with few surface cracks, and will more readily compact.

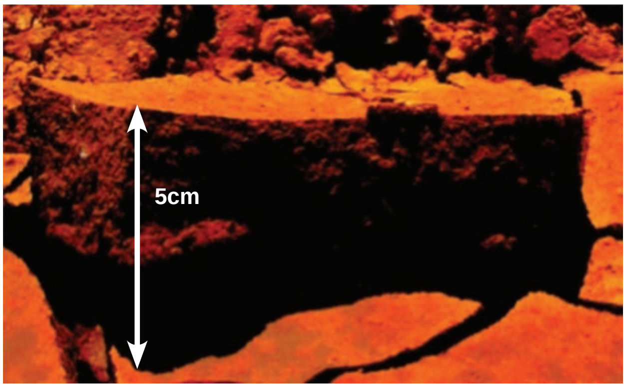


Figure 1: Thick surface crust formed in sodium affected soil within two weeks of preparing the tilth for planting.
(Source J. Chapman 2007)

More work is required to prepare the tilth for new crops, at higher energy costs and wear and tear of machinery.

Crusts also promote runoff of applied irrigation water and rainfall. Large surface cracks can also result in preferential flow of the applied water which results in uneven wetting of soil in the upper root zone.

Sodic soils tend to compact and set hard when they dry. This then slows down the rate at which irrigation and rainfall water can soak in. Loss of water through surface runoff and the slower drainage makes it more difficult to leach out unwanted sodium and salt from the root zone.

Carrots, onions and other seed crops cannot push through thick surface crusts. While the stems of developing transplants can be damaged and allow entry of soil diseases. Poor crop establishment and uneven growth will result in yield loss and extended harvest times increasing cost.

Impact on root development

The healthy root ball shown is highly branched and has distinctive white, actively growing tips.

Figure 2: Healthy root ball.
(Source: http://www.hotbiscus.com/images/rootball.jpg)

Compacted soil layers contain less stored soil water available for plant uptake. This combined with poor soil aeration results in soil lacking oxygen which roots require to function efficiently. In severe cases this can result in rotting roots and the trigger for soil disease to cause more damage.

Crops with poorer root systems have to spend more energy to access the soil water, energy that would otherwise go into growth. Limited movement of soil water to the roots may result in plants suffering water stress earlier even though the soil may appear moist. Plants are more likely to wilt during heat waves because they cannot take up the soil water rapidly enough to replace amounts lost through the leaves and stems.

Stronger, compacted soil can cause deformation of carrots, parsnips and other root crops making the product unsuitable for human consumption, with considerable loss of profit.

Figure 3: Cavity spot in carrots aggravated by low calcium and high sodic soils.

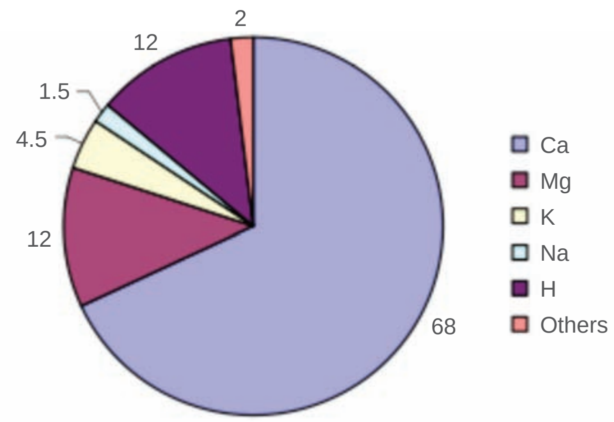
Plants need to continually develop feeder roots throughout the growing season to take up nutrients with limited mobility in soil such as phosphorus, potassium, calcium, and magnesium. Root development can be severely restricted in stronger (compacted), poorly aerated soil, leading to nutrient imbalances. Adequate phosphorus is needed to aid cell division of the developing root tip while calcium strengthens the cell walls to assist penetration of the root tip in soil.

Calcium is associated with the surfaces of clay in soil, along with magnesium, sodium and potassium. The relative balance of these "exchangeable cations" is important for crop nutrition. In a well balanced soil cations are present within a defined ratio.

When the exchangeable sodium percentage is greater than 6% then the availability of exchangeable potassium, calcium and magnesium is restricted, the plants will take up sodium instead of potassium. This weakens cell walls and the ability of the plants to control moisture loss from their leaves. As a result plants will be susceptible to wilting in warm weather.

The pi chart of optimal percentages below shows that in healthy soils, calcium (Ca) is the dominant exchangeable cation whereas sodium (Na) is relatively minor. Hydrogen is also important in helping to buffer the soil against pH changes.

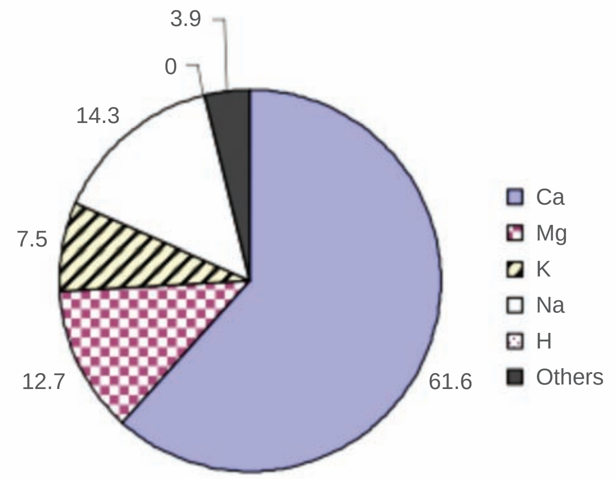
Desired Balance of Exchangeable Cations (Per Cent)



Continual irrigation with water high in sodium promotes displacement of exchangeable calcium by sodium.

The example below is from a soil that is affected by sodicity. Calcium levels have dropped to the low 60%, and hydrogen has been lost. Soils that are low in hydrogen ions are alkaline. Sodic soil has a highly alkaline pH, which adds to nutritional problems.

Exchangeable Cation Percentages of a Sodic Soil



As pH becomes more alkaline phosphorus and trace elements including iron, manganese, copper and zinc become less available to plants even when there is an adequate reserve.

Do you have a salinity or sodicity problem?

Sodium chloride is a common component of salty water sources. It is therefore important to test both the soil and plant tissue to determine whether you have either a salinity or sodium problem, or both.

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TS16

Part 2: Testing and Amelioration

Part 1 described how sodium in irrigation water displaces essential plant nutrients and the hydrogen ion off clay particles (Figure 1). Without amelioration, compaction, high alkalinity and nutrient imbalances will result in soil degradation and loss of crop productivity.

To identify the combination of sodium, salinity and alkalinity, and potential impacts on crop productivity requires **both** soil and plant tissue test. These will also provide a decision making tool to identify the most suitable amelioration program.

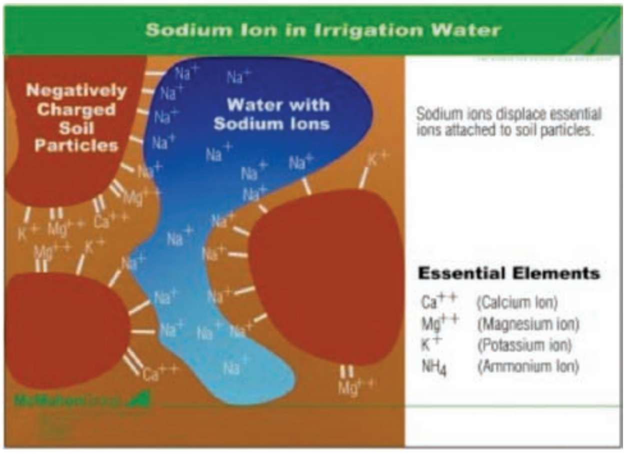

Figure 1: Displacement of calcium and other essential ions off clay surfaces by sodium in irrigation water.
(Source: www.mcmahongroup.blogspot.com)

Soil testing

The question you need to ask is does your soil have adequate calcium levels? The only way of knowing is to have your soils tested, at least once annually. Soil is ideally sampled from the 0–20cm layer or to the depth that amendments can be incorporated. The ideal times are early post harvest for perennial crops. If vegetable crops are incorporated back into the soil post harvest, the soil should be sampled afterwards. However sample early enough to allow sufficient time to spread and incorporate amendments. Check with your district agronomist.

The calcium is accessed by plants through sites present on the surfaces of clay and organic matter. To tell whether there are enough sites (clay and humus) to allow plant roots to access the available cations including calcium, check that your soil test analysis provide you with a measure of the CEC (Cation Exchange Capacity).

Soil salinity is measured by electrical conductivity of either a suspension of 1 part soil to 5 parts water ($EC_{1:5}$), or by saturated paste extract (EC_e). Sodicity requires analysis of exchangeable cations from which the exchangeable sodium percentage is calculated.

A good laboratory will provide a report of likely effects on your cropping system, but without a plant tissue test you may only be receiving half of the information you require to make an informed management decision.

Plant Tissue Test

Tissue testing during the growing period will identify potential nutrient imbalances and limitations to crop productivity **before** visible signs appear. Nutrient imbalances of the essential micro nutrients are more likely to occur as a result of excess sodium hence it is important to have these analysed along with the macro nutrients. When using brackish water plants will always take up some chloride, but they do not have to take up the sodium. If the plants are taking up too much sodium, then both sodium and chloride will be high in the tissue test. Therefore sodium and chloride should also be tested.

Both the timing and type of plant tissue that is sampled is very specific for each crop type. Always seek advice from your agronomist or the testing laboratory (identified on the label of the test kit).

Standard timing of tissue testing for commonly grown crops on the Northern Adelaide Plains are:

- Almonds – mid January
- Grapes – just prior to flowering
- Greenhouse vegetable crops – early flowering and just prior to harvest

It is very common for tissue testing to be performed outside the standard timing. It is important that an experienced agronomist is consulted so that the testing is interpreted correctly if this testing is required.

Amelioration

Managing sodicity is commonly approached by reducing the amount of sodium associated with clay surfaces by applying calcium, and leaching the mobilised sodium out of the crop root zone (Figure 2). The soil and plant tissue tests will identify the most suitable type of calcium required for amelioration especially, as selection of the appropriate ameliorant must always consider the potential impact on soil pH and salinity. Calcium comes in forms such as gypsum, lime, dolomite lime, and various liquid forms.

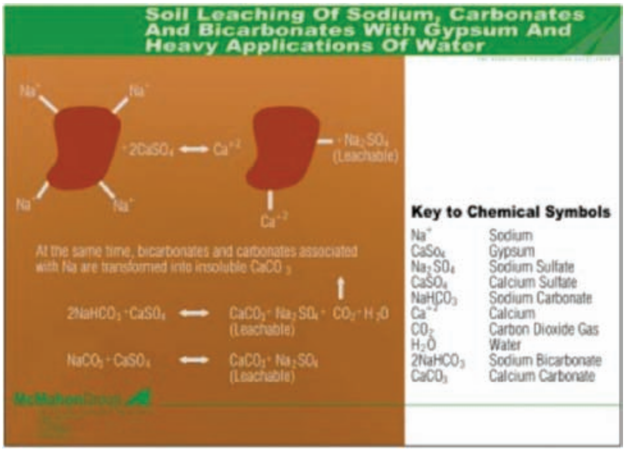

Figure 2: Amelioration of sodicity by adding calcium.
(Source: www.mcmahongroup.blogspot.com)

If the soil is not showing a sodicity problem and the plant tissues test is showing high chloride then leaching irrigation for managing salinity will remove chloride from the root zone. Leaching is outlined in TS12 Fig 3 and TS14.

It is important to find an impartial agronomist capable of discussing plant tissue test results alongside the soil test results.

There is a range of products that will instigate displacement of sodium ions from the clay and humus particles so that it can be leached away from the root zone of the soil profile. These will also provide a valuable input of calcium. Also remember that calcium is a fertiliser required by plants for growth and is just as important as nitrogen and potassium based fertilisers.

Do my plants have damaged roots?

It is also important to ask the question do I have poor or damaged root growth. Crops with damaged roots may not be able to respond to fertiliser as they are not able to actively explore the soil to take up the nutrients. Test results showing adequate nutrient levels in soil, but deficiencies in plant is an indication of root damage, especially if the latter show that there is more than 1 or 2 deficient nutrients in the leaf test. For example high sodium and chloride is usually associated with calcium deficiency and sometimes nitrogen deficiency. Trace elements may also be deficient and it is likely that plant roots will be shutting down. Diseased or physically damaged roots will often result in nutrient deficiencies in plant tissue tests irrespective of soil nutritional status, hence regularly inspect root systems.

Organic Carbon

Frequent cultivation of soils in annual vegetable cropping systems can reduced organic carbon to very low levels. Without the organic ‘cements’ the soil crumbs will not break easily, reducing the effectiveness of applying calcium. It is extremely important to also improve the organic carbon content of the soil by cover cropping and application of compost to raise the number of sites which can hold the exchangeable cations for plant uptake. It is ‘what you don’t see that does the job’.

This requires allowing the added organic carbon to break down as it would in nature. Plants and compost are broken down by microbes with the organic materials mixed in through the action of worms and other soil dwelling organisms. This natural process can be promoted by mowing or spraying off the cover crop, and minimising cultivation. Cultivation promotes breakdown of organic materials and weakens the soil structure by exposing fresh surfaces to the microbes responsible for its breakdown and oxygen that they use in this process.

Over the longer term cultivating the cover crop back into the soil will not effectively raise organic carbon levels.

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