Salinity and potato production

Impact of groundwater quality on management of centre pivot grown potato crops

Nutrients play a vital role in the optimal production of fresh, processing and seed potatoes. Where imbalances exist, it can lead to a multitude of issues from general poor shape, size and skin blemishes, to storage quality, frying properties and flavour.

Applying the right nutrients at the right time and in the right quantity will help to reduce inputs while maintaining or increasing yields. Regular monitoring and assessments of your natural resources will facilitate sustainable potato production.

1. Monitoring for improved management
2. **Know your salts to better manage potato nutrition**
3. Managing hydrophobic soils in potato production
4. Organic soil amendments, biologicals & biostimulants

This fact sheet is the second in a series of four on salinity and potato production in South Australia. 'Know your salts' takes an in-depth look at salinity and the salts that affect both plant health and soil structure, and guide potato nutrition.

Although these fact sheets focus on potato production in salt affected regions of South Australia, the information can be applied to other salt affected regions of Australia.

Salinity in South Australia

Landscapes and soils across South Australia range from deep sands to shallow sands over light clays and are all affected by salinity to varying degrees. Salinity not only affects the soil but can also affect the irrigation water applied.

While sodium and chloride are the main reason for a decline in productivity in many parts of Australia, South Australia's groundwater resources used for irrigation is hard and high in sodium, chloride and bicarbonates. This provides multiple challenges for optimal potato production. Irrigation water supplies measured across the three major potato growing regions show salt levels often four to five times above upper desirable limits for potatoes.

The application of highly saline irrigation water to potato crops not only directly impacts potato plants but can also add salts to the soil profile. Salt accumulation within soils affects nutrition and can also directly affect soil structure impacting on potato emergence, growth and harvest.

Irrigation and cropping can exacerbate salinity in prone areas so it is paramount to know your salts and where they exist for optimal nutrition and irrigation management.

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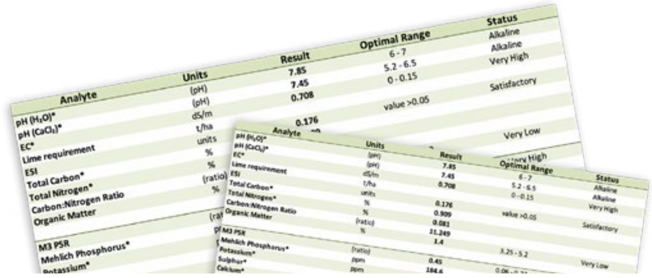
Know your salts to better manage potato nutrition 2



Analyte	Units	Result	Optimal Range	Status
pH (H₂O)*	(pH)	7.85	6-7	Alkaline
pH (CaCl₂)*	(pH)	7.45	5.2-6.5	Alkaline
EC*	dS/m	0.708	0-0.15	Very High
Lime requirement	t/ha			
ESI	units	0.176	value >0.05	Satisfactory
Total Carbon*	%			
Total Nitrogen*	%			
Carbon:Nitrogen Ratio	(ratio)			
Organic Matter				
M3 PSR				
Mehlich Phosphorus*				
Potassium*				

Test results – What salts are what?

For optimal potato nutrition, it is important you understand the salts in your cropping system and their levels in the soil, water and plants. All nutrients must be in balance for plants to function at their best. Only one element in excess, such as sodium, can cause deficiencies in others such as calcium and potassium. Here are the important salts and how they can affect potato quality and yield.

Chloride

Chloride is one of the most soluble anions of salt which can have a major impact on potato production.

Irrigation water high in chloride applied directly to potato crops using an overhead form of irrigation, can scorch the plant leaves where browning on the leaf edges quickly becomes evident (Figure 1).

For potato production areas, scorching of the leaves during irrigation on hot windy days increases the likelihood and severity of scorching that will occur. With the onset of climate change and higher summer maximum temperatures, the risk of scorching only increases. Scorching of plant leaves reduces the health of the plants due to impaired photosynthesis, akin to damaged solar panels, with overall decreased leaf growth and area.

Figure 1: Yellowing of plant leaves and scorching of leaf tips, early signs of salt stress in young potatoes.

Measuring salinity

- Electrical conductivity (EC) is the most common unit of salinity measurement used for soils and water.
- ECw and ECse values classify the severity of salts, along with determining the tolerance of crops to salts.
- The EC value is a measure of all dissolved salts present, which may include the cations sodium, magnesium and calcium, and anions chloride, sulphate, carbonate and bicarbonate. These salts vary in their level of solubility further complicating salinity and EC readings.

Upper chloride levels in irrigation waters were measured in the three potato growing regions in South Australia including the Mallee (382ppm), South East (554ppm) and Northern Adelaide Plains (898ppm). All measured well over the upper desirable limit of 200ppm.

Elevated soil chloride levels above 200mg/kg decreases plant health and vigour as the plant roots are unable to absorb water and other nutrients efficiently. Chloride directly competes with nitrate, preventing the uptake of nitrate by plants. With the application of extremely high chloride levels in irrigation water, the potential for chloride toxicity in the plants is high, along with accumulation within the soil.

Soil chloride levels were measured across the three major potato growing regions, with the highest levels observed in the Northern Adelaide Plains at 209mg/kg. The other two regions had significantly lower chloride levels, <100mg/kg, however results showed chloride increased from the start to the end of each potato irrigation season.

Chloride levels in plant sap tests also varied region to region. The Mallee and the South East observed some of the highest increases in chloride, often doubling or tripling in levels from start to season end, with levels up to five times greater than the upper desirable range.

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Sodium

- Sodium is the most soluble salt of the cations and collectively with chloride can be very damaging to plant health and productivity.
- For irrigation water the upper desirable level for sodium is 74ppm.

The three potato growing regions showed variability with sodium levels in irrigation water ranging from 140ppm as the lowest recorded level in the Mallee, through to 608ppm in the Northern Adelaide Plains – eight times greater than the upper desirable limit.

- High soil sodium levels can lead to nutritional imbalances, as well as poor soil structure, increasing potential compaction, decreasing porosity which in turn impedes water infiltration and decreases the ability of plant roots to function properly.

Soil sodium levels varied between regions from the start to end of the season and between the sands and clays. The upper desirable range for soil sodium is 90mg/kg. At the start of the season, the majority of sites had sodium levels well below 90mg/kg (10 – 34mg/kg), apart from some of the higher clay-based soils that ranged from 85 – 145mg/kg. End of season accumulation levels ranged from two to six times greater that start of season levels.

- Sodium levels are typically measured as Exchangeable Sodium Percentage (ESP).

Soils with elevated ESP >6% are referred to as sodic. Sodic soils can be highly dispersive, losing structure quickly when wet and forming hard setting crusts on the soil surface when dry. The high proportion of sodium relative to other cations enables the sodium to remain bound to the clay particles, but displaces other cations. This weakens the bond between the soil particles, resulting in dispersion and poor soil structure.

Plant sap sodium levels generally varied throughout the season regardless of region, most likely due to individual management practices combined with inherent site conditions. Elevated sodium levels in soil solution can lead to imbalances in plant calcium and potassium. Deficiencies in plant calcium can lead to reduced strength in cell walls, reduced resistance to various diseases and decreased storage capacity of tubers. Potassium deficiencies add to reduced disease resistance and inefficient uptake of nitrogen, can impact specific gravity of tubers and generally lead to poor plant health and reduced yield.

Figure 2: Salt scalding and the accumulation of salts on the tops and sides of potato mounds in South Australia.

Figure 3: Surface crusting of a potato mound with salt crystals formed just below the surface.

Calcium

- Calcium is a very important nutrient required for healthy potato production, playing a significant role in early cell division and growth through to tubers approximately 5mm in size.
- Research has shown that for calcium to reach the developing tubers, it can only be absorbed via the stolons, and therefore must be present in a highly available form during early cell division. In this regard, calcium is unlike other nutrients, only moving upwards through the plants, not downwards from the leaves.
- For healthy potato production, you need to minimise the effects of excess sodium on soil nutrition and structure, ensuring healthy root growth with the correct balance of available nutrients.
- Typical liming agents used to adjust pH will not provide sufficient available calcium, and instead growers should be sourcing quality products with highly available calcium to the developing stolons.

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Other water quality issues

pH

- Alkalinity of soil and water is very common in potato growing regions of South Australia.
- Alkalinity of soils is caused by the presence and weathering of calcium carbonate rich parent material. This is typically seen in drier regions that experience uneven rainfall events.
- Irrigation water with a pH above 7 is considered alkaline.
- Irrigating with alkaline water that is high in carbonates can increase soil sodium levels due to the relatively insoluble nature of calcium carbonates present, effectively removing the calcium availability from solution.
- pH of soils and water can reflect the salinity and sodicity of soils, creating both nutrient imbalances and poor soil structure.

Hardness

- Water hardness relates to high levels of dissolved calcium and/or magnesium salts, along with other cations such as iron, manganese, aluminium and zinc.
- The classification of water hardness is based on levels of calcium carbonate, with most South Australian waters testing Hard to Very Hard, 2.5 to 5 times greater than the upper desirable limit of 100mg/L.
- Irrigation with hard water can lead to increased sodium accumulation within the soil, and sometimes calcium deposits can lead to blocked irrigation equipment.
- Hard water used in irrigation is a key factor in reducing the adoption of variable rate irrigation due to the blockages that can readily occur.
- High iron levels in irrigation water can lead to the build-up of iron loving bacteria in irrigation lines and nozzles, creating blockages and potential inefficiencies in the application of irrigation water to crops.

What salts are in fertilisers?

Fertilisers play a significant role in managing salinity in potato crops, with all fertiliser materials varying in their relative salt content and solubility. Muriate of potash, potassium chloride, is one fertiliser that can add further chloride to saline systems with already high chloride levels. Since chloride can be quite toxic to potatoes, the use of other potassium fertilisers, albeit slightly more expensive, may end up saving you money in the long-term.

Quality liquid fertilisers such as calcium thiosulphate, can supply readily available calcium and sulphur for plants in a solution that is significantly more soluble than gypsum. The timely application of calcium thiosulphate to both processing and fresh market potato crops in South Australia has assisted with flushing chloride and sodium from the root-zone of tubers, reducing plant chloride levels up to 30 per cent.

With chloride competing with nitrate for plant uptake, the application of potassium nitrate or magnesium nitrate will assist with nitrate uptake in saline environments compared to traditional ammonium-based fertilisers such as urea.

Organic amendments such as compost may also contain salts, so if you are applying composts to your potato crops and soils, make sure you request a nutrient analysis prior to application to avoid adding further salts.

Irrigation management

Irrigation water is essential for potato production to occur but there are few cost-effective ways to change the quality of this water. In some agricultural regions, 'shandying' highly saline irrigation water with fresh water can assist with lowering salt loads. Unfortunately, this option is rarely available in South Australia.

Some regions rely on wastewater for irrigation, which can also be highly saline, and when stored in on-farm dams can become exposed to potential evaporation during hot summer days, further increasing salts.

Irrigation management and scheduling can assist with salinity management within the root-zone of potatoes. Ensuring potato mounds remain wet helps to prevent the drying and wetting patterns that lead to evaporation and accumulation of salts within the root-zone. Regular irrigation assists with pushing or flushing the harmful salts down and away from the developing tubers, helping to balance nutrients.

Amending irrigation water quality ahead of application is not a cheap or easy process. However, the salts within the root-zone can be managed more easily and cost effectively if we monitor and measure regularly. Management options will be discussed in more detail in the following two fact sheets.

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References and further reading

Carbonate/Bicarbonate in Soils and water (2014) | Adaptation of Potato to High Temperatures and salinity – A Review, Levy D and Veilleux R E (2007) | American Journal of Potato Research 84:487 – 506 | Soil Salinity: Effect on Vegetable Crop Growth. Management practices to Prevent and Mitigate Soil salinisation, Machado R M I & Serralheiro R P. (2017) | Irrigation Best Practice Water Management for Potatoes – A Guide for Growers, ADAS, TAG (The Arable Group) & the British Potato (2005) | Soil wealth & Integrated Crop Protection (2019) Managing Salinity in Vegetable Crops, Hort Innovation | Salinity Glovebox Guide Tasmania, NRM North (2009) | Calcium misunderstood in potatoes. Crop Production Magazine, 89-90, de la Pasture L (2016) | Irrigation water quality, Agriculture NSW – Field Vegetables Prime Fact 1164, New South Wales DPI (2011).