MANAGING DRY SALINE SOILS IN THE UPPER NORTH AND YP

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This case study aims to outline the issue of dryland salinity in the Upper North Region. With a summary of key findings from current research exploring improved management practices.

What is dryland salinity?

Dryland salinity is an issue that limits agricultural production in the lower Broughton region. Soil types in this region consist of ancient flood plains, characterised as alluvial soils with moderate to high salt content and poor soil structure. Accumulation of salts in the surface soil, limits crop establishment, unless flushed from the surface with rainfall. Improving ground cover decreases salt accumulation in the topsoil, by reducing the capillary rise of salt to the surface as water evaporates.

Why does it occur?

Soils in this region have inherently high salt levels at depth, with the depth and concentration of salts varying across paddocks. Visually, salt affected areas appear as a mosaic pattern across the landscape, with patches of good and poor plant growth. Within a small area, establishment and crop performance can vary from a viable plant stand to nothing as shown in the photo above. The effect of salinity is more evident during seasons of low rainfall, as rainfall dilutes salts in the surface soil by washing them into the profile.

Figure 1. Variation in the growth of barley on a paddock in the lower Broughton region as a result of varying salt concentrations in surface soil.

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There are two ways in which salinity occurs, either through ground-water driven salinity or dry saline land.

Dry saline land, often referred to as 'magnesia patches', occur due to the presence of natural salts in the upper part of the soil profile and are not associated with a water table. Salts moves up and down the soil profile via two pathways, rainfall (leaching salts down) and evaporation (pulling salts up via capillary rise). For this reason, managing ground cover is so important as it impacts evaporation rates, which drives salt accumulation in the surface soil.

The other way in which salinity occurs in this region is through rising ground water tables this is known as **'ground water driven salinity'.** This occurs when deep rooted perennial plants such as shrubs, saltbush and trees are removed in favour of annual crops such as cereals, pasture and legumes. The change from perennial to annual plants, results in rising groundwater tables as they remove less water from the system. This is because, they do not grow year-round, have a lower tolerance to salinity and are shallow rooted. When the water table is within a metre of the surface, water can be drawn up through capillary rise. As this saline water evaporates, salts accumulate at the soil surface. In extreme situations, this results in the formation of a white scald or crust.

Salinity in this region has been extensively mapped and is best described as non-water table salinity higher in the landscape and groundwater driven in the valleys. Most saline land occurs near the coast, where the distinction between ground water driven and non-water table salinity becomes blurred.

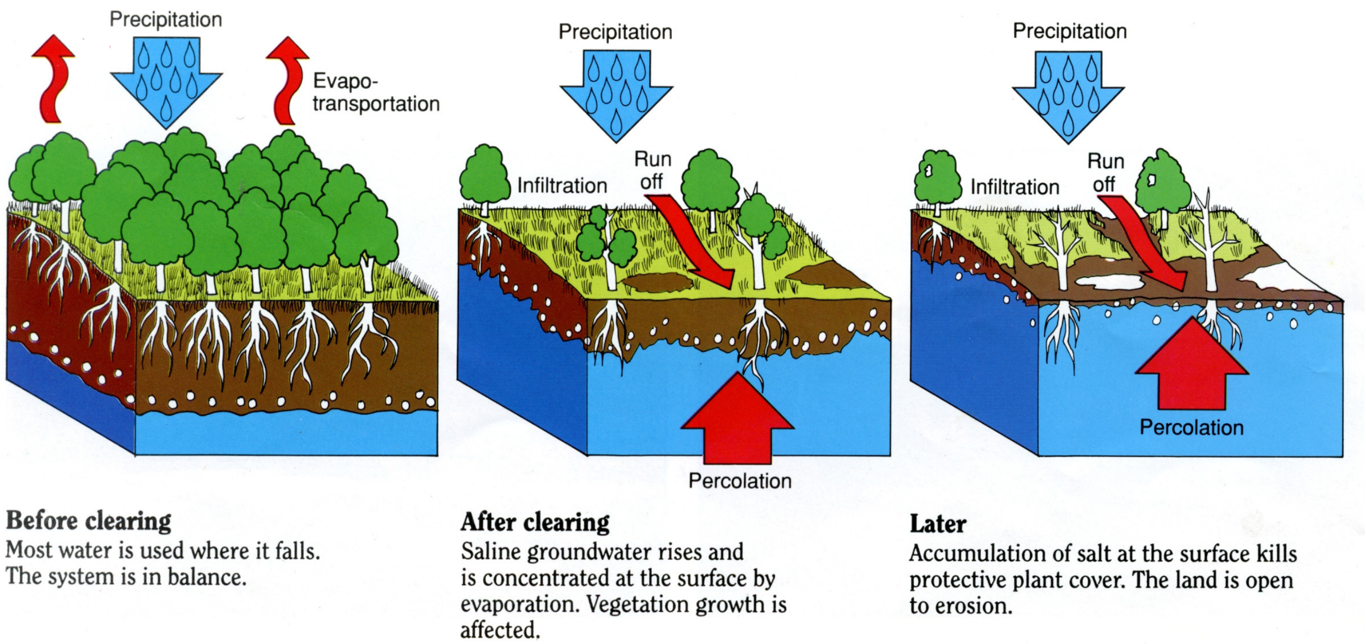

Figure 1. Example of how groundwater driven dryland salinity occurs.

Why is it an issue?

Salinity reduces the ability of plants to access water and nutrients. Symptoms of high salinity include stunted plant growth and bare areas. Annual plants on saline land experience very high salinity as the soil first wets up, with increasing moisture the impact of salinity decreases as water fills the soils pores and salts leach down the profile. As the season finishes and the soil dries, salinity levels increase. Salt bush and some native shrubs are tolerant to high salinity levels, whilst most annual crops are not.

How can it be measured?

Salinity is a measure of the soluble salts in soil or water. Sodium chloride ($NaCl$) is the most common salt in groundwater in SA. When measuring salt levels within a paddock, soil sampling methods are different if assessing soils for the suitability of establishing annuals or perennials. For annuals and if establishing perennials from seed, soil tests should be taken from the topsoil (0-10cm). Whilst if seeking to understand the impact salinity may have on established perennials, a subsoil sample should be taken.

There are three main measures of salinity, they include.

- The electrical conductivity (EC) of a solution or soil and water mix in the field or laboratory.
- The apparent electrical conductivity using an electromagnetic induction (EM) device.
- Chemical analysis of total dissolved salts (TDS) of water or soil in a laboratory to identify and measure ion concentrations.

Table 1.
Salinity classes in electrical conductivity as EC1:5 or ECe for different soil textures.

Salinitiy Class (dS/m)	Sands (EC1:5)	Loams (EC1:5)	Clays (EC 1:5)	ECe Range
Non-Saline	0-0.14	0-0.18	0-0.25	0-2
Slightly Saline	0.15-0.28	0.19-0.36	0.26-0.5	2-4
Moderatley Saline	0.29-0.57	0.37-0.72	0.51-1	4-8
Highly Saline	0.58-1.14	0.73-1.45	1.01-2	8-16
Severly Saline	1.15-2.28	1.46-2.9	2.04-4	16-32
Extemely Saline	>2.28	>2.9	>4	>32

EC 1:5 can be converted to ECe which corrects the value for soil type. This is achieved by multiplying the EC value by the associated conversion factor based on soil texture, in the table below. **ECe is generally considered the preferred measure of soil salinity.**

Table 2. Texture conversion factors (soil salinity)

Soil texture	Conversion Factor
Sand to clayey sand	14.0
Sandy loam to clay loam	9.5
Clay	6.5

How can we manage dryland salinity?

Management is difficult in areas where scalds occur as mosaic patterns (eg in the Lower Broughton region). Incorporating deep rooted perennial plants is the best option, but is not necessarily the most profitable in the short term. Other options include:

- Keep saline areas covered with stubble by retaining as much stubble as possible
- Apply mulch (sand or straw) if economically viable
- Revegetation of saline areas with fodder shrubs such as salt bush
- Grow species with greater salt tolerance (e.g., barley, canola, oats)
- Reduce or eliminate stock grazing on these areas

What crops are most tolerant to salinity?

The table below demonstrates the expected tolerance of various crop types to salinity measured as (ECe).

Table 3. Yield decrease (%) from selected crops to soil salinity (Source: Maschmedt, 2004a)

Crop	Yeild decrease expected				
	0%	10%	25%	50%	Maximum
	Soil ECe (dS/m)				
Barley	8.0	10.0	13.0	18.0	28.0
Wheat	6.0	7.7	9.5	13.0	20.0
Beans	1.0	1.5	2.3	3.6	6.5
Lucerne	2.0	3.4	5.4	8.8	15.5
Strawberry Clover	1.5	2.3	3.6	5.7	10.0

Recently, research work has been undertaken in the lower Broughton and Tickera region investigating opportunities to improve crop yield and ground cover on soils impacted by salinity. This work was made possible through the Future Drought Fund Drought Resilient Soils and Landscapes Project "Building resilience to drought with landscape scale remediation of saline land". The key findings to date from this work are presented below.

TRIAL 1: EXPLORING THE TOLERANCE OF DIFFERENT CROP SPECIES TO SALINE SOIL

The image below is of a replicated mixed species trial comprising the crop types listed in Table 4 above. The trial was sown on a saline soil near Tickera SA in 2022 by Trengove Consulting. The ECe across this site varied from 5.4-37 in the top 10 cm with chloride levels ranging from 520 - 4,800 mg/kg in the surface and subsurface. The critical level for chloride for annual crops is 300 mg/kg. In this year, oats were the highest yielding species at .9 t/ha followed by safflower, barley and field peas. Wheat, triticale, lentils and vetch were the lowest yielding species trialled.

TRIAL 2: EXPLORING THE USE OF AMENDMENTS SUCH AS SAND, STRAW AND GYPSUM ON THE GROWTH AND ESTABLISHMENT OF BARLEY ON SALINE SOILS.

Both sand and straw act like a mulch when spread on the soil surface, reducing evaporation and decreasing the accumulation of salts in the topsoil, this helps to improve crop establishment and growth. Gypsum whilst not acting like a mulch, can improve soil structure by increasing water availability on sodic soils. Depending on the source of gypsum, salt levels in the product can be high and may exacerbate the issue. A trial was conducted in the lower Broughton region in 2022 to explore the effect of these amendments on barley establishment and grain yield on a saline soil (Figure 3).

The topsoil (0-10cm) at this trial site returned an average ECe value of 9.9 indicating a high level of salinity. ECe levels increased to 20 in the 40-60cm zone indicating levels were severe in the subsoil.

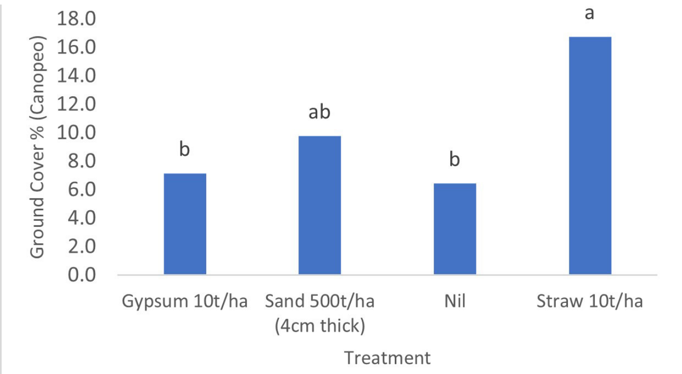

Figure 3. Ground cover (%) at GS30 of barley and impact of sand, straw and gypsum compared to control (no amendment) near Port Pirie in 2022. Means that share letters in common do not significantly differ from one another.

Image: Replicated small plot trial prior to sowing near Port Pirie in April 2022, note straw treatments were applied post sowing.

TRIAL 3: EXPLORING THE USE OF AMENDMENTS SUCH AS SAND AND STRAW ON THE PERFORMANCE OF LENTILS ON A SALINE SOIL AT TICKERA SA

Application of sand and straw improved lentil growth and grain yield in the first year of trial work. Sand rates above 650 t/ha and straw rates above 6.6 t/ha resulted in lentil grain yields of 0.45 t/ha – 0.57 t/ha compared to the control which yielded 0.12 t/ha (Figure 4).

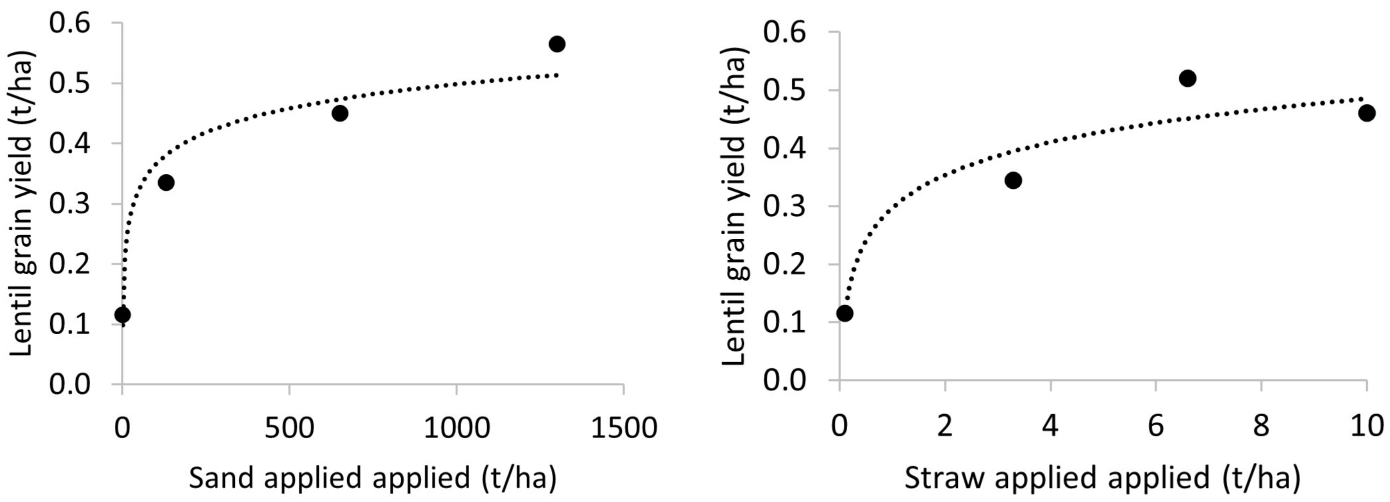

Figure 4. Straw (left) and sand (right) applications (t/ha) impact on the grain yield (t/ha) of lentils sown on a salt scald near Tickera SA, courtesy of Trengove Consulting.

CONCLUSIONS

The logistics of spreading sand on areas of high salinity is difficult unless the source is in close proximity or within the paddock. Spreading straw is more practical as a means to ameliorate saline patches. However, the longevity of response is key if such practices are to achieve positive economic benefits in the long term. Further investigation is needed to determine this, before such a practice should be implemented on a wide scale. With respect to crop selection, one year of trials has suggested that oats, safflower and canola are worth exploring further on saline soils.

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