Information Sheet

5. IRRIGATION

5.11 Properties of saline/sodic soils and their reclamation

Introduction

Sugarcane is regarded as relatively insensitive to salts when compared to other crops such as maize and soya. However, excessive salt loads in soils will negatively affect sugarcane yields. Affected soils and rivers are confined mainly to those areas of the sugar industry receiving a mean annual rainfall of less than 760 mm, i.e. the Mpumalanga and Swaziland lowveld, Pongola and river valley regions such as Nkwalini and Heatonville. Serious problems occur mainly on the poorly drained, highly dispersed grey soils derived from Beaufort sediments, Dwyka tillite and Vryheid sediments, and black swelling clays derived from basalt, dolerite and Pietermaritzburg and Vryheid shales.

Figure 1. Salt load of the soil in the foreground was too high for sugarcane to survive.

Types of salt affected soils

Based on their chemical reaction with the soil and their effect on plant growth two types of salts are commonly found in soils. **Plant essential salts** include calcium, magnesium and potassium and when present in excessive amounts they will make it difficult for plants to extract water from soils.

Sodium is considered a **nonessential salt** and will cause soil structure to collapse (dispersion) and toxification of plants when present in large quantities.

Depending on the type of salts present, excess quantities can cause soils to be either saline, sodic or a combination of both known as saline-sodic (refer to Table 1).

Saline soils (Witbrak) are not commonly found in the sugar industry. In saline soils, calcium and magnesium ions predominate over sodium and pH is less than 8.5. These soils have a high essential salt content which restricts water uptake and eventually plant growth. Salinity induces water stress which is evident in cane by premature wilting, scorching of the leaves, restricted growth and, in severe cases, death of the plant (Figure 1). Soil structure is not affected which means that these salts can be leached with water provided the soil has excellent drainage properties or are artificially drained.

Sodic soils (Swartbrak) have a low essential salt content but a high level of exchangeable sodium attached to the clay particles. The pH is higher than 8.5 and soil structure has collapsed due to dispersion. A surface crust is present which causes poor aeration, water infiltration rates and permeability (rate of water movement in soil) is reduced and nutrient uptake is restricted (Figure 2). In extreme cases sugarcane might die due to sodium toxicity (Figure 3).

Saline-sodic soils (Witbrak) are most commonly found in the sugar industry. Although the essential salts are present in substantial quantities, exchangeable sodium is dominant over calcium and magnesium. Soil pH is less than 8.5 and soil structure is affected (Table 1).

Table 1. Categories and properties of saline and sodic soils.

Type	Electrical conductivity* (mS/m)	SAR** (ESP)	Dominant cation(s)	pH (water)	Effect on soil structure
Normal	< 400	< 6 (< 7)	None	< 8.5	None
Saline	> 400	< 6 (< 7)	Mainly Ca and Mg	< 8.5	None (osmotic interference of plant uptake of water)
Saline-sodic	> 400	> 6 (> 7)	Ca, Mg and Na	< 8.5	Early stages of dispersion
Sodic	< 400	> 6 (> 7)	Mainly Na	> 8.5	Severe dispersion and possible Na toxicity

Figure 2. Sodic "Swart brak" soils where sodium salt is dominant, the pH is greater than 8.4 and the soil is in an advanced dispersed condition

Figure 3. Death of sugarcane over a large area due to sodium chloride toxification following flooding of the area by sea water.

Causes of salt build-up in soils

Salts are either inherent to a soil (coming from the parent material) or are imported through irrigation water. Salinisation is generally caused by poor water management, i.e. inadequate drainage coupled with excessive irrigation, which results in a rise in the level of the water table. Salts (particularly sodium chloride) dissolved in the ground water reach the soil surface by capillary movement, causing small patches of saline-sodic soil. Such 'brak' development usually takes many years to manifest, as was the case in the Pongola Irrigation Scheme where serious problems only appeared after about 40 years of continuous cane production. Once excessive salts in soils becomes visible on the surface, the size of the affected area will grow rapidly. Salinisation tends to be more prevalent in severe drought years.

Salinity

Electrical conductivity (EC, measured in milli-siemens per metre or mS/m) is a measure of the total soluble salts in the soil solution. The salinity rating of a soil profile is based on the mean EC value of the soil saturation extracts for depths 0 - 30 cm, 30 - 60 cm and 60 - 90 cm. Table 2 indicates how sugarcane growth is affected by increasing soil EC value. The effects of salinity on sugarcane the effects of salinity can be influenced by factors such as clay content, drainage properties of the soil, irrigation water quality, and the sugarcane variety.

Table 2. Salinity hazard to sugarcane based on electrical conductivity (EC) value of the soil saturation extract.

Soil EC value (mS/m)	Salinity level	Effect on sugarcane growth
0-200	Non saline	None
200-400	Slightly saline	Slightly affected
400-600	Moderately saline	Severely affected
>600	Strongly saline	Very severely affected

Sodicity

The mean sodium adsorption ratio (SAR, the proportion of sodium to calcium plus magnesium) of the soil saturation extracts for depths 0 - 30 cm, 30 - 60 cm and 60 - 90 cm. are used as an index of sodicity. Different soil forms vary in their sensitivity to sodium and on this basis are divided into three groups and assigned different critical SAR values (Table 3). When the measured SAR value is greater than the critical SAR value for a particular soil form, the soil is rated as being sodic.

Table 3. Sodicity hazard to cane based on critical SAR values for various soil forms.

Critical SAR 6	Critical SAR 10	Critical SAR 15
Generally poorly drained, highly dispersed grey soils derived mainly from Dwyka tillite, Vryheid sediments and sandy alluvium.	Mainly slowly draining black swelling clays associated with dolerite Pietermaritzburg and Vryheid shales, Swazi basic rocks and heavy alluvium.	Mainly well drained, non-dispersive soils associated with with Recent Sands and other parent materials in upland positions.
Estcourt	Arcadia	Champagne
Glenrosa	Rensburg	Inanda
Katspruit	Bonheim	Cartref
Longlands	Mayo	Clovelly
Mispah	Milkwood	Dundee
Kroonstad	Tambankulu	Fernwood
Swartland	Willowbrook	Griffin
Valsrivier		Hutton
Wasbank		Oakleaf
Westleigh		Shepstone
		Shortlands

Assessing soil salinity/sodicity

To determine the salt status of soils samples should be taken from a few places where sugarcane growth is normal and where its is affected. Sampling depths should be 0 - 30 cm, 30 - 60 cm and 60 - 90 cm. The purpose of taking samples from these depths is to enable FAS to comment meaningfully with regard to the origin of the salt problem and to give appropriate advice to manage the problem. Measurements that will be conducted in the laboratory include pH, SAR and EC. See Tables 1, 2 and 3 for the interpretation of these parameters on soils and sugarcane growth.

Reclamation of salt affected soils

Saline, saline/sodic and sodic soils can be successfully reclaimed and converted into highly productive soils. Depending on the condition of the soil, this could potentially be an expensive, difficult and time consuming operation. For this reason, a policy of 'prevention is better than cure' should be adopted from the outset. To achieve this the following is recommended:

- Know the salt load of your irrigation water and how it changes from summer to winter.
- Know the salt load in your soil.
- Know the tolerance of your crop to salinity and sodicity.
- Ensure adequate surface and subsurface drainage as it is essential to permit effective leaching of accumulated salts from the soil. Drainage alone is able to bring about substantial reductions in soil salinity and sodicity.

Reclamation of saline soils

- To reclaim a saline soil (high in essential salts, low in sodium) salts must be leached out using heavy applications of irrigation water of acceptable quality provided the soil's drainage system is effective. The application of chemicals such as gypsum or sulphur is not required.

Reclamation of saline/sodic and sodic soils

- Since these soils are normally dispersed and water infiltration rates significantly reduced, high amounts of organic matter (i.e. > 100 t/ha filter cake) should be incorporated to improve structure, water infiltration and aeration.
- To reclaim a sodic soil, also apply gypsum at 5-10 tons/ha to promote replacement of sodium on the clay particles by calcium, and to improve soil structure (see Figure 3). Consideration should also be given to acidify the soil using sulphur, for instance, at 6 tons/ha.
- Since sodic soils are normally highly dispersed and therefore slowly permeable, the ameliorants should be incorporated as deeply as possible (300 mm) and thoroughly mixed with the soil to improve the rate of sodium's replacement by calcium and its leaching from the soil profile.
- Following the application of ameliorants, the soil must be leached with heavy applications of good quality water provided the soil's drainage system is effective. To dissolve gypsum, the general guideline is to apply 100 mm irrigation water (or sum of irrigation and rain) for every ton of gypsum.

Effect of water quality on soil salinity/sodicity

It is vital to assess irrigation water for quality (its salt load). Water samples must be submitted to an analytical lab such as FAS to analyse it for pH, SAR and EC. However, it is important to note that the SAR and EC values will need to be corrected in order to facilitate meaningful interpretation of the effect of the water on soil quality. To do this the amount of bicarbonates in the water sample is taken into account because it will remove Ca from the soil resulting in an increased soil SAR value. Additionally, the dilution effect of regional rainfall on EC values (EC is an indication of the total salt load in the water sample) is taken into account to calculate effective EC (EEC). It is thus important to supply the regional annual rainfall value when water samples are submitted for quality assessment

Further reading

Van Antwerpen R, Miles N, Rhodes R, Weigel A, Wettergreen T and Van Der Laan M (2013). Soil management for sugar-cane production in Southern Africa.

Addendorf MA (2016), SASRI Information Sheet 5.6 Chemigation:Guidelines for choosing chemicals.

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