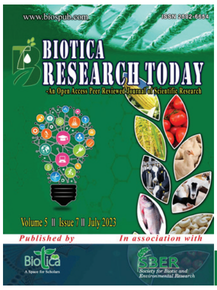

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Techniques of Vegetable Production for Sodicity

G. Sidhdharth*, K.R. Vijayalatha and PJ. Nivethaa

Dept. of Vegetable Science, Horticultural College and Research Institute for Women, Tamil Nadu Agricultural University, Tiruchirappalli, Tamil Nadu (620 027), India

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Corresponding Author

G. Sidhdharth

: gsidhdharth75@gmail.com

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Abstract

Sodic soil is one of the foremost reasons that lead to hindering crop productivity. Soil productivity is more adversely affected due to sodic soil which leads to more root diseases, restricted root development and poor ventilation. Plant growth has a negative effect on exchangeable sodium that is present in soil. Saline soil contains ample dissolved salt that can deplete the fertility of soil. Clay particle's negative charge absorbs excess sodium under natural conditions and lead to weakening of force holding together the clay particles. Dense layers and block pores are formed in the clay particles when it gets dried. Air and water flow restrictions weaken the aggregation, which leads to structural collapse of the soil.

Keywords: Clay, Productivity, Sodic soil, Sodium

Introduction

A soil having an exchangeable sodium percentage in excess of six will be characterized as sodic soil. This indicates that more than 6% of the total exchangeable cation are mainly comprised of sodium in the soil. Dispersion of sodic soils leads to break down and these individual clay particles block the pore spaces of soil. This dispersion of sodic soils leads to slow internal drainage, poor water infiltration, germination problems and surface crusting. The soil might become mostly impermeable and this could be a poor environment for growing plants if subsoil dispersion occurs.

Salinity and Sodicity

Saltiness of soil or water generally refers to Salinity. Salinity rises as the amount of salts in the soil that are soluble in water increases. Sodicity involves no chlorine; whereas, salinity involves chlorine. Salinity in the soil and water could be measured using chloride content and electrical conductivity (EC) (Table 1). As saline soils are drained, leaving sodium and chlorine, soil gets converted to sodic from saline conditions. Sodicity can also result from using leaching irrigation water to remove salts from the root zone (using fresh water with little or no salt content). Chlorine may leach from heavier soils, but too much sodium may accumulate in the root zone because it binds to clay particles (Stavi *et al*., 2021).

Sodicity in the soil lead to:

1. Reduction in the water flow through soil limits leaching and may cause accumulation of salt over time and the saline subsoil development.

2. Crusting and sealing are formed due to dispersion in the soil surface, which then hinders the water infiltration.

3. Subsoil dispersion speeds up the erosion and this result in the formation of gullies and tunnels.

4. Structure-less soils, cloddy and dense soils, as it inhibits aggregation.

Indicators of Soil Sodicity

1. Poor crop growth or vegetation and poor water infiltration.

2. Dense or hard subsoil and surface crusting.

3. Columnar or prismatic structure in the subsoil.

4. Soapy nature on wetting and working for soil textures.

5. Shallow rooting depth, pH more than 8.5 and cloudy water in puddles.

Impact in Growth and Quality of Vegetables

1. Growth, seedling emergence and establishment of crop were affected due to crusting and hard setting of soil.

2. Poor drainage could lead to frequent water-logging in the crops.

Article History

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Table 1: Difference between saline and sodic soils (Hussain *et al.*, 2019)				
Classification	Exchangeable Sodium Percentage	Electrical conductivity	pH	Sodium Adsorption Ratio
Saline soil	<15	>4	<8.5	<13
Sodic soil	>15	<4	>8.5	>13
Saline Sodic soil	>15	>4	<8.5	>13

3. Dense soil restricts the root growth as it contains only little air.

4. Less amount of calcium, potassium and magnesium in the soil will be accessible and taken up by plants if the exchangeable sodium is large. Plants replace some of these cations, particularly potassium, with sodium.

5. Trace elements availability (*e.g.*, Fe, P, Zn and Mn) is reduced since sodic soil has an alkaline pH.

Reclamation for Sodicity

Reclamation using chemical amendments can be made for sodic oil and it is widely classified into three groups (Gangwar *et al.*, 2020):

1. Calcium salts such as calcium chloride and gypsum which were soluble in nature.

2. Acid or acid forming substances such as iron sulphate, sulphuric acid, lime-sulphur, aluminium sulphate and pyrite.

3. Less soluble calcium salts such as ground limestone.

Applying Gypsum or Lime

When gypsum or lime is applied correctly on sodic soils, the dispersion and sodium exchange percentage are decreased while the soil structural stability is increased. On the surface of soil particles, calcium ions take the place of certain sodium ions, thus creating improved structure of the soil that allow leaching of the sodium ions (Figure 1 and 2).

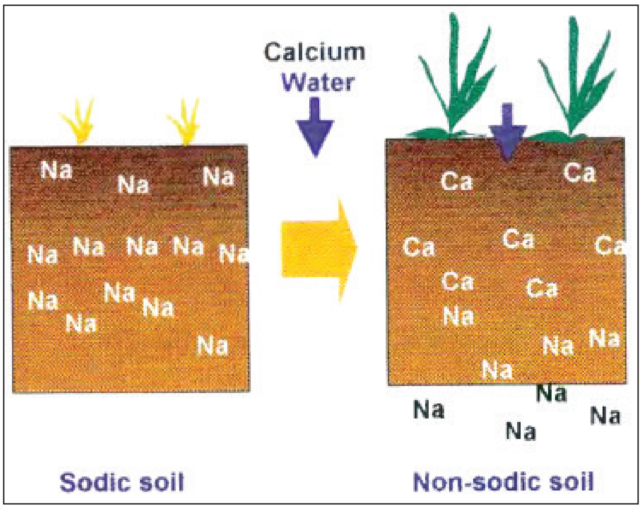

Figure 1: Sodic and non-sodic soils (Nelson *et al.*, 2001)

Lime Application

Only soils with an acidic pH (less than 4.8 for calcium chloride) should be treated with lime. Since lime does not dissolve in alkaline soils, it serves no purpose there. There will be some acidity in the sodic soils that were present in heavy rainfall regions.

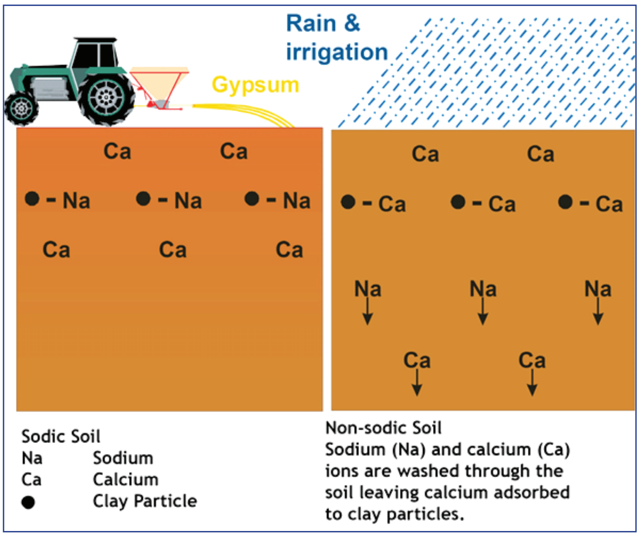

Figure 2: Application of gypsum to sodic soils (Rengasamy *et al.*, 2010)

Gypsum Application

Application of Gypsum should be done on the soils that were alkaline. Stability in the structure of the sodic top soils was improved rapidly with the application of gypsum. Adding gypsum directly to the subsurface of the soil using slotting or trenching and deep cultivation is the most effective and quickest way to treat sodic subsoil. Some of the sodium ions on the surface of soil particles are replaced by calcium ions, improving soil structure and facilitating leaching of sodium ion. Generally, gypsum is required more if the percentage of clay particle is higher and on lowering the soil organic matter content (Table 2).

Table 2: Application of gypsum based on the sodicity ranking			
Dispersive behaviour	ESP (%)	Application rate	
		Acid soils	Alkaline soils
Low	6-10	0-15	1.0-2.5
Moderate	10-15	2.5	5.0
Severe	>15	5.0	5.0

Minimisation of Cultivation

As sodic soils are more vulnerable to water erosion and degradation, cultivation should be minimised. Non-inversion tillage should be used for dispersive subsoils if cultivation is found necessary. Based on the need, strip tillage can also be used.

Quality of Water used for Irrigation

There are many management options depending on whether the soil is non-saline sodic or saline sodic. Non-saline sodic soils are frequently dispersive if fresh water is supplied. A switch from salty to fresh (low-salt) water can cause a sodic soil's soil structure to collapse. In this case, amount of low-salinity water should be gradually increasedA. Saline-sodic clay soils are often less dispersive than non-saline sodic soils. Additionally, fresh water can be used without dispersion.

Addition of Organic Matter

In order to keep soil from physically breakdown, organic matter helps to retain soil particles together. This facilitates salt leaching out more readily. The ideal application for organic materials uses lime or gypsum. The retention of stubbles, brown and green manuring, phase crop with a perennial pasture with deep roots, such lucerne, are methods to increase soil organic matter.

Most of the soil contains insoluble calcium compounds. These calcium compounds are more easily dissolved when organic material, compost and plant roots are used. It is generally agreed that the soil physicochemical and geographical characteristics have a role in selecting the best recovery strategy. The physical characteristic changes that take place in the root zone that are triggered by roots include the release of air trapped in bigger conducting pores, the development of macropores, and the production of alternate wetting and drying cycles.

Plant-Microbe Interaction

Interaction between plants and microbes is advantageous, and it is a successful technique for soil reclamation. Rhizosphere bacteria have been discovered to significantly boost the amount of nutrients that plants absorb or to manufacture the compounds that support plant growth and improve soil quality. Resulting in the manufacture of proteins and substances that are used in plant defense systems, or by inducing some changes in the structure of the cell wall, microbes induce physiological and biochemical changes that indirectly encourage plant growth and prevent the negative effects of Phyto-pathogenic organisms. Biological approaches in the soil rely at the calcite existence and are somewhat slower than chemical procedures to produce beneficial effects.

Deep-Ripping

In order to break up compacted and poorly formed soils, deep ripping could be used. The area will get overly damp because tilled soil disperses more readily. Large clods of dispersive soil can be raised by ripping and it can also expose harmful substances like salt and boron to the air. Deep ripping on a tiny test strip or subsoil testing is typically practiced prior to ripping. After being deeply ripped, the soil is stabilized by adding extra organic matter, gypsum (in acid soils), and lime. Tramline farming systems stop the loosened soil from being compacted again.

Deepened Seedbeds or Raised Beds

Using this method, hard-setting top soils or soils that are prone to water logging are lifted and aerated, thus enhancing structure of the soil along with drainage. Gypsum and organic matter is added to topsoil that is structurally unstable to keep the strengthened structure. Raised beds are more essentially to have a drainage channels. In sodic subsoils, strong roots enable plants to create root pathways that later crops can use to their advantage.

Stabilizing and Protecting the Ameliorated Soil Structure

• *Tramline farming* is an efficient means of minimizing the improved soil traffic that might otherwise induce compaction and soil structure degradation.

• To prevent top soils from being eroded by water and growing in organic matter, appropriate *soil cover* should be maintained (for instance, by retaining stubble).

• *Livestock management*: Removal of livestock from wet, structurally unsound soils to prevent structure loss and compaction.

• *Drainage*: Excess water is removed by using shallow relief drains to reduce water-logging. Using upslope grade banks, surface water flow is channelled to secure disposal locations far from vulnerable dispersive soils.

Conclusion

Due to flocculation of the clay particles, dispersion level is reduced shortly through the use of water that is saline. Inadequate rate of leaching accumulates more sodium in the soil which make it more sodic and management will be more challenging. Sodicity in soils, in contrast to salinity, occurs naturally and cannot be reversed except by adding recycled gypsum. Reduced tillage and an increase in organic matter can lower the amount of soil dispersion in a sodic environment, but they won't change the exchangeable sodium percentage of the soil.

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