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Management of Salt Affected Soils

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Abstract

In India, the extents of salt affected soils are increased enormously to 6.74 million hectare. Soil salinity is one of the major problems restricting crop production in the arid and semi arid regions of the world. Area distributed in India *viz*., Saline soil (2.96 mha) and Sodic soil (3.78 mha) and in which the worst affected areas were found in Gujarat and Rajasthan states. These problem soils namely, saline, sodic, saline sodic soils should be managed through integrated approach for the reclamation through various practices to nullify these problems for better crop yield as well as soil fertility. Mainly we could recommend the practices of soil amendments, crop rotation, choosing of crops, soil drainage, leaching, gypsum application, lime application for reclamation of salt affected soils for sustainable development for crop production and soil fertility management.

Introduction

The salt-affected soils are normally occurring in the track of arid and semiarid regions where the evaporation, transpiration and evapo-transpiration severely exceeds the precipitation. The accumulated ions by various process causing salinity or alkalinity include sodium, potassium, magnesium, calcium, chlorides, carbonates and bicarbonates. The salt-affected soils can be primarily classified as saline soil, sodic soil and saline-sodic soil.

Characteristics of Salt affected Soils

The following table describes the characteristics of salt affected soils.

Saline Soils

Saline soils commonly have visible salt deposits on the surface and are sometimes called “white alkali” soils. Most salts in soil solution have a positive effect on soil structure and water infiltration. Therefore, water penetration is not a major concern with saline soils. Salts in the root zone can reduce crop yield by making it difficult for roots to extract water from the soil. Salts increase soil osmotic potential, causing water to move from areas of lower salt concentration (plant tissue) into the soil where the salt concentration is higher. High salt concentration in the soil can cause plants to wilt even when soil moisture is adequate.

Sodic Soils

High exchangeable sodium, high pH, and low calcium and magnesium combine to cause the soil to disperse, meaning that individual soil particles act independently. The dispersion of soil particles destroys soil structure and prevents water movement into and through

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the soil by clogging pore spaces. Sodic soils often have a black color due to dispersion of organic matter and a greasy or oily-looking surface with little or no vegetative growth. These soils have been called “black alkali” or “slick spots.”

Table 1: Characteristics of Saline, Sodica and Saline sodic soil

Characteristics	Saline soil	Sodic soil or alkali soil	Saline sodic soil
Soil pH	~ 8.5	> 8.5	< 8.5
EC	> 4 dSm^{-1}	< 4 dSm^{-1}	> 4 dSm^{-1}
ESP	< 15	> 15	> 15
Content in soil	Excess soluble salts of Ca, Mg and Na	Presence of excess exchangeable sodium on the exchange complex	These are transition soils. They contain sodium saturate and excess soluble salts

Saline-Sodic Soils

Saline-sodic soils generally have good soil structure and adequate water movement through the soil profile. They can have the characteristics of either a saline or sodic soil, depending on whether sodium or calcium dominates.

Management of Salt Affected Soils

Sodic Soil Management

1. Irrigation Water Management: More frequent irrigations minimize the adverse effects of salt in the soil.

2. Application of Gypsum: Water soluble calcium salts (Gypsum, Ca, Cl), acid forming substances example; Pyrites, sulphuric acid, iron sulphite, Aluminium sulphate, lime-sulphur, sulphor rock. Calcium salts of low solubility example; Ground limestone, byproduct lime of sugar factory.

Gypsum:

$$Na_2CO_3 + CaSO_4 \Rightarrow CaCO_3 + Na_2CSO_4$$

$$(Clay)\ Na + CaSO_4 \Rightarrow Ca\ (Clay) + Na_2SO_4$$

Sulphur:

$$2S + 3O_2 \Rightarrow 2SO_3$$

$$SO_3 + H_2O \Rightarrow H_2SO_4$$

$$H_2SO_4 + Na_2CO_3 \Rightarrow CO_2 + H_2O + Na_2SO_4$$

3. Application of organic manure, green manure, crop residues produces weak acids and helps in creating temporarily acidic conditions help in reclamations.

4. Irrigation water management leading with water of good quality.

5. Crop rotation with good quality rice, dhaincha, dhaincha-rice-berseem.

6. Frequent irrigation of small quantity of water is successful in irrigation management practices.

7. Tree plantation is very useful.

8. Tolerant and Sensitive crops:

a) Rice and Dhaincha- Tolerant to sodic.

b) Wheat and Bajra- Moderately tolerant to sodic.

c) Legume (Mash) and Lentil- Moderately tolerant to sodic.

d) Wheat, Cotton, Barley, Tomato are tolerant to sodic.

Crops that are able to withstand excess moisture conditions resulting in short term oxygen deficiencies are also more tolerant of sodic conditions.

Saline Soil Management

Saline soils have excessive concentration of natural soluble salts, mainly chlorides, sulphates and carbonates of calcium, magnesium and sodium. In such soil Electrical Conductivity (EC) of saturated soil extract is more than 4 ds/m, Exchangeable Sodium Percentage (ESP) is less than 15 and pH is also less than 8.2. Such soils are called “saline soils” or “white alkali” or “solonchack” soils and recommended interventions for such soil are listed namely, a) Field bunding, land shaping, construction of irrigation channel, construction of peripheral bunds, sluice gate, farm ponds/ water harvesting structure, *etc*.; b) Construction of surface/sub-surface drainage as per need of the area for lowering the ground water level & also for flashing salt accumulated upper soil layer crop root zone; c) Green manuring & its mulching into soil for increasing organic carbon in the soil with thrust on use of FYM; d) Application of soil test based chemical fertilizers and micro-nutrients to ensure judicious and balance use of such fertilizers; e) Growing of suitable crops/ horticultural/ agroforestry species including food, fuel & fodder plantations as per land capabilities depending upon soil and slope conditions for complete one year; f) Casualty replacement and post planting care, horticulture and agroforestry plantation for about three years; and g) Organization skill development and awareness programme for adoption of recommended package of practices on continuous basis to prevent reoccurrence of problem soils.

Saline-Sodic Soil Management

Saline-sodic soil containing calcium carbonate ($CaCO_3$) is common in arid and semiarid regions. Since the $CaCO_3$ dissolution rate is too slow to supply enough Ca^{2+} for ion exchange, an acid or acid former, such as gypsum, sulfuric acid, or organic matter can be applied as a soil amendment to enhance $CaCO_3$ dissolution. Gypsum

is the most prevalent agricultural soil amendment used for reclamation of sodic soil. It decreases the damaging effects of high sodium content in irrigation water because of its high solubility, ease of use, and low cost. Several studies have shown that a high application of gypsum to reclaim saline-sodic soils increases the removal of excess Na^+ from soil and causes a significant reduction in electrical conductivity and sodium adsorption ratio within the soil.

The relative effectiveness of gypsum and sulfuric acid has received the most attention because they are widely used as reclamation amendments. Most recently, crops or crops residues and synthetic polymers have been included in efficiency studies. Gypsum is mainly blamed for its slow reaction but much popular due to its low cost and availability. One of the major shortcomings in gypsum use is its application at uniform rates, which lower its efficiency because of the special variability under the salt affected soil conditions. The efficiency can be increased if applied at variable rates according to the gypsum requirements of the soil but again it needs extra analysis that may not be economical in some cases. The significance of organic matter has been proven through its effect on improving the physical conditions of soils for crop growth besides its role as fertilizers. Various organic amendments such as manure and compost have been investigated for their effectiveness of reclamation of saline sodic soils. In general, the additions of organic amendments alone have very little effect on reclaiming saline sodic or sodic soils.

Conclusion

The integrated approach for the reclamation of salt affected soils could overcome the affected soils in India, mainly through the crop rotation, leaching, drainage, scrapping, alternate cropping system, frequent irrigation with less quantity of water, application of green and green leaf manures, lime and gypsum application *etc*., the awareness should be made by the officials and scientists from agricultural department and agricultural universities to the farmers for reclamation of salt affected soils for better soil health.

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