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Salinisation: Causes and Prevention

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The term 'salinity' strikes fear into the hearts of many farmers. Some call it the white death because it conjures up images of lifeless, shining deserts studded with dead trees. Fears of the 'white death' seem justified. It threatens agricultural productivity in 77 m ha of agricultural land of which only 45 m ha (20% of irrigated area) is irrigated. Salinity affects the growth, development and productivity of crops worldwide. In India, more than 8.6 m ha of lands are salt affected and poses problem to productivity of crops. Wheat, the second important staple food crop of India, faces salinization problem resulting in decrease in average yield by more than 50%, due to which stable supply of food becomes a question mark in light of increasing global population which is expected to touch 9 billion in 2050.

Introduction

A worldwide phenomenon of accumulation of excess salts in the root zone results in a partial or complete loss of soil productivity. The problem of soil salinity is widespread in arid and semi-arid regions though salt affected soils are also found extensively in sub-humid and humid climates, particularly in the coastal regions where the ingress of sea water through estuaries & rivers causes large-scale salinization. Soil salinity is also a serious problem in areas where groundwater of high salt content is used for irrigation. The most serious salinity problems are being faced in those arid and semi-arid regions of the world where irrigation is essential to increase agricultural production to satisfy food requirements. Irrigation in these areas requires skilled management. Failure to apply principles of efficient water management may result in wastage of water. Over-watering and inadequate drainage results in waterlogging, loss of cultivable land and salinity problems which reduce the soil productivity. Nearly 50 percent of the irrigated land in the arid and semi-arid regions has some degree of soil salinization problems. This shows the magnitude of the problem that must be tackled in order to meet future global food needs. It is generally agreed that the future food needs of increasing population will be met by directing the efforts of all concerned towards improving the level of management of soils already under cultivation, and by bringing under plough the potentially arable soils which are presently uncultivated.

Soil salinity is a major impediment in achieving potential crop yields. Measures to combat desertification, preventing and controlling water logging, salinization and sodication by modifying farming techniques in a regular and sustained way using an integrated approach is need of present day agriculture. The problems of salt-affected soils are old but their magnitude and intensity have been increasing fast due to large-scale efforts to bring additional areas under irrigation in recent decades. The problems have been made worse by development of irrigation systems without adequate provision for drainage and are being aggravated by poor water management practices and unsound reclamation procedures.

Origin of Salts

The presence of excess salts on the soil surface and in the root zone characterizes all saline soils. The main source of all salts in the soil is the primary minerals in the exposed layer of the earth's crust. During the process of chemical weathering which involves hydrolysis, hydration, solution, oxidation, carbonation and other processes, the salt constituents are gradually released and made soluble. The released salts are transported away from their source of origin through surface or groundwater streams. The salts in the groundwater stream are gradually concentrated as the water with dissolved salts moves from the more humid to the less humid and relatively arid areas. The predominant ions near the site of weathering in the presence of carbon dioxide will be carbonates and hydrogen-carbonates of calcium, magnesium, potassium and sodium; their concentrations, however, are low. As the water with dissolved solutes moves from the more humid to the arid regions, the salts are concentrated and the concentration may become high enough to result in precipitation of salts of low solubility.

Salinity and Plant Growth

Excess soil salinity causes poor and spotty stands of crops, uneven and stunted growth (Fig. 1) and poor yields, the extent depending on the degree of salinity.

Fig.1. Salt tolerant v/s salt sensitive (Source: http://www.growflow.com.au/soil-salinity-reduction/)

The primary effect of excess salinity is that it renders less water available to plants although some is still present in the root zone. This is because the osmotic pressure of the soil solution increases as the salt concentration increases.

Reclamation and Management of Salt Affected Soils

1. Salt leaching
2. Drainage

1. Salt Leaching

The amount of crop yield reduction depends on such factors as crop growth, the salt content of the soil, climatic conditions, etc. In extreme cases where the concentration of salts in the root zone is very high, crop growth may be entirely prevented. To improve crop growth in such soils the excess salts must be removed from the root zone. The term reclamation of saline soils refers to the methods used to remove soluble salts from the root zone. Methods commonly adopted or proposed to accomplish this include the following:

- **Scraping:** Removing the salts that have accumulated on the soil surface by mechanical means has had only a limited success although many farmers have resorted to this procedure. Although this method might temporarily improve crop growth, the ultimate disposal of salts still poses a major problem.
- **Flushing:** Washing away the surface accumulated salts by flushing water over the surface is sometimes used to desalinize soils having surface salt crusts. Because the amount of salts that can be flushed from a soil is rather small, this method does not have much practical significance.
- **Leaching:** This is by far the most effective procedure for removing salts from the root zone of soils. Leaching is most often accomplished by ponding fresh water on the soil surface and allowing it to infiltrate. Leaching is effective when the salty drainage water is discharged through subsurface drains that carry the leached salts out of the area under reclamation.

2. Drainage

Provision of adequate drainage measures is the only way to control the groundwater table.

- **Surface drainage:** In surface drainage, ditches are provided so that excess water will run off before it enters the soil. However the water intake rates of soils should be kept as high as possible so that water which could be stored will not be drained off. Field ditches empty into collecting ditches built to follow a natural water course. A natural grade or fall is needed to carry the water away from the area to be drained.

- **Subsurface drainage:** If the natural subsurface drainage is insufficient to carry the excess water and dissolved salts away from an area without the groundwater table rising to a point where root aeration is affected adversely and the groundwater contributes appreciably to soil salinization, it may be necessary to install an artificial drainage system for the control of the groundwater table at a specified safe depth.
- **Filter materials:** These are sometimes placed around subsurface drains primarily to prevent the inflow of soil into the drains which may cause failure, and/or to increase the effective diameter or area of openings in the drains which increases inflow rate. Two types of materials are generally used:
  1. Thin sheets such as of fibre glass or spun nylon and
  2. Sand and gravel envelopes or other porous granular materials
- **Pump drainage:** The chief drawback of gravity drainage systems is their inability to lower the water table to an adequate depth. Pumping groundwater in areas where a suitable permanent aquifer exists is often an effective means of lowering the water table.

Maintenance of Drainage Systems

A subsurface drainage system normally requires little maintenance if it is properly designed and installed. The outlet ditch should be kept free of the sediment and the tile outlet should be protected against erosion and undermining. If a drain line becomes filled with sediment or roots the line should be uncovered at some point downstream to locate the obstruction. Roots of nearby trees can also block subsurface drains. For this reason shrubs and trees growing adjacent to a tile line should be removed. Weed growth must be controlled and the caving in of the sides requires continuous attention in order that the entire drainage system continues to work efficiently.

Conclusion

Salt in soils comes from basic fertilizers, salty irrigation water and naturally-occurring salts. Salt build up is the result of a lack of effective leaching of salts through soils. Salt management in soil is a major challenge for growers. The challenge is to effectively manage soil salinity and sodium (Na) in a cost-effective manner, using appropriate combinations of irrigation management, soil management, and soil amendments.