Reclamation and Management of Alkaline Soils

Salt-affected soils have excess of soluble salts and/or excess of exchangeable sodium with accompanying high pH. Both these conditions degrade the soils and render them inhospitable for normal crop production (in absence of special soil and crop management measures). Soils having soluble salts in excessive amounts are unable to supply water to plants due to osmotic stresses. As a consequence, plants are unable to grow normally in salt-affected soils. The salt content may be an inherent characteristic of the soil or the result of salts being brought up from the deeper soil layers through capillarity or directly due to application of saline or alkali groundwater for irrigation. Saline soils typically have salt encrustations on the surface.

Categories of Salt-Affected Soils

Salt-affected soils are categorized into two broad classes, viz (i) saline soils; and (ii) alkali (sodic) soils. Such a classification facilitates understanding of the genesis and management of the salt-affected soils on the basis of the influence of two common kinds of salts (i.e., neutral and alkali salts) on soil properties and plant growth. In soil testing laboratories, using USSL Staff (1954) criteria often a third category of salt-affected soils, namely saline-alkali soil, are also designated. It only,

Classification of Salt-Affected Soils

Soil type	pH_s	EC dSm^{-1}	$\frac{Na^+}{(Cl^- + SO_4^{-2})}$	SAR $(mmol/L)^{-½}$	ESP %
Normal	<8.2	<4	<1	<13	<15
Saline	<8.2	>4	<1	<13	<15
Alkali	>8.2	<4	>1	>13	>15

Gupta R.K. and Abrol, 1990

however, complicates issues and provides no indication whether soils belonging to this group be managed as saline or as alkali soils. This leads to considerable confusion as to how these soils should be reclaimed and managed.

Reclamation and management of saline and alkali soils differ considerably in terms of gypsum usage, irrigation and leaching schedules and choice of crops and cropping system. It is, therefore, warranted that soils belonging to saline-alkali branch are correctly diagnosed for adopting effective reclamation measures. Soils in saline-alkali branch can be easily apportioned into saline and/or alkali soil class through use of electro-neutrality criteria. A sodium to chloride and sulphate ratio $\{Na^+/(Cl^- + SO_4^{-2})\}$ greater than 1.0 suggests that a part of the positive charge due to sodium ions, is neutralized by carbonate ions. This points to the presence of sodium carbonates, at time not so easily detected in aqueous soil paste extracts, even when it is present in soils (Gupta and Abrol, 1990). Use of $\{Na^+/(Cl^- + SO_4^{-2})\}$ ratio, together with other indices, differentiates soils in saline-alkali branch into saline and/or alkali soils, an essential prerequisite for their proper management and reclamation for crop production.

Reclamation of Alkali Soils

Gypsum ($CaSO_4$ $2H_2O$) or other relatively calcium salts or acid formers like elemental sulphur and pyrites of iron can also be used to reclaim alkali soils and to treat irrigation water having residual alkalinity. Gypsum is applied onto properly-leveled and bunded fields and water is ponded for several days for salts to leach the reaction products down through the profile. Application of gypsum is often not required for management of all of the so-called "saline-alkali" soils as mentioned above. Saline-alkali soils with predominantly the neutral soluble salts (high SAR saline soils) behave like saline soils. They may not need gypsum usage and can be reclaimed by leaching with good quality waters. Provision or improvement of drainage in saline soils, having shallow water table, produces the desired results of speeding up the reclamation process in such soils.

Damage

For reclaiming saline and alkali soils, good drainage is the most important consideration. Often, provision of drainage and supply of fresh irrigation water are sufficient measures to reclaim saline soils. Salts are washed down with the percolating water through the soil profile and are leached into the drainage.

Tillage

Application of gypsum changes the soil reaction (ESP and pH) in the surface layer to a greater extent than in the sub-surface soil layers. Tillage should be restricted to the top 10cm of soil in which the gypsum should be incorporated and planted with rice (*unpuddled transplanted rice*) to initiate the reclamation process. Deep plowing brings the partially reclaimed subsoil to the surface, adversely effecting yield of the following wheat crop. Reclamation programs will be more effective by not bringing soil from the deeper layers to the surface. The use of organics facilitates dissolution of naturally-present calcite and also the passage of water down into profile of the gypsum amended oils.

Bed Planting

Furrow irrigated raised beds (FIRB) effectively double the depth of the reclaimed alkali soil rooting profile. Changing from flat layouts to raised beds alters the geometry and hydrology of the system and offers greater control over irrigation, drainage and their impacts on transport and transformation of nutrients. Water moves horizontally from the treated furrow surface into the raised beds through subbing and is pulled upwards through capillarity, evaporation and transpiration. Bed planting reduces irrigation water requirement by 25%-50% while the growth and yields of transplanted rice on beds can be comparable or more than traditional rice culture. Permanent beds also avoid the need for deep plowing in subsequent years and excellent wheat crops have been obtained from FIRBs in partially-reclaimed alkali soils.

Puddling

Alkali soils already have poor drainage and are highly impermeable to water movement. Puddling of alkali soils further degrade the soil structure, and can facilitate the formation of subsurface plow pan further restricting the percolation of the water through the soil profile. Reduced infiltration and passage of water reduces leaching of the gypsum-reaction products out of the soil profile and thereby slows down the process of reclamation of alkali soils. Therefore, puddling should be avoided for several years after initiating reclamation program on alkali soils.

Rice as the Fist Crop

Rice likes ponded water conditions for longer periods and is a sodicity-tolerant crop. In alkali soils, not amended with gypsum or other ameliorants, water stagnates for long periods after an irrigation and rainfall event. Because of prolonged ponded water conditions generally prevailing during the monsoon season, rice is the preferred choice of the farmers in early stages of the reclamation programs. The rice crop should be transplanted on unpuddled soils. Deep plowing should be avoided and tillage should be restricted to the top 10cm depth in amended soils. Both deep plowing and puddling are counter-productive in reclamation and unhelpful in obtaining higher yields in the succeeding wheat crop.

Grouping Irrigation Waters

Irrigation with low quality irrigation waters may cause salinity, and infiltration problems or even cause specific ion toxicity. Such effects of irrigation may adversely affect crop production. Depending on the characteristic features of the groundwaters in use and the indices that describe restrictions in their use (salinity, sodicity hazards on crops and soils), low quality irrigation waters can be broadly grouped as (i)saline and (ii) alkali waters. Researches have shown that irrigation water quality standards which are unmindful of the monsoonal climate conditions of the Indian sub-continent, cannot adequately describe the salinity and sodicity hazards on crops and soils. Very often, the waters which would be termed unsuitable on the basis of criteria followed by USSL Staff (1954) are in continuous use with South Asian farmers.

Depending on the degree of restrictions, the two water quality classes have been further sub-grouped as in Table 1.

Table 1. Water Quality Groupings of Irrigation Waters

Water Quality Class	ECiw dSm^{-1}	SAR $(m\ mol/L)^{-1/2}$	RSC $meqL^{-1}$
Normal	<2	<10	<2.5
Saline			
i. Marginally-saline	2-4	<10	<2.5
ii. Saline	>4	<10	<2.5
iii. High SAR saline	>4	>10	<2.5
Alkali			
i. Marginally-saline	<4	<10	2.5-4.0
ii. Alkali	<4	<10	>4.0
iii. Highly alkali	<4	>10	>4.0

The problem of alkali soils is often aggravated when groundwater having more than 4.0 meq/L of residual sodium carbonates (RSC) are used for irrigation. Water termed as "alkali water or highly alkali" are unsafe for irrigation. The use of such waters for irrigation turns normal soils into alkali soils, necessitating gypsum use again after few years. On the other hand, irrigation waters in saline category have excess of neutral soluble salts and their continuous use causes salinity to the detriment of most crops except the salt-tolerant ones. If infiltration rates of soils are adequate, gypsum may not be needed for a long period.

The management of saline irrigations in crop production depends on the climatic and soil conditions, and the way these waters are used for irrigation. Therefore, besides chemical quality of irrigation waters, considerations of soil texture, crop tolerance, crop rotation, quantity of available canal water supplies, rainfall and concentration of solutions due to evapotranspiration (salt concentration factor) are of great importance. Accordingly, low quality waters are used either in cyclic use mode, or by blending them with fresh canal water supplies or both.

Blending Irrigation Water

On-farm storage tanks, used for captive fish breeding in canal water, can be conveniently used for blending water for irrigation (Gupta *et al.*, 2000). These tanks can also be used to store excess surface run-off flows during rainy season for irrigation use in the dry season. The alkali waters from tubewells, when mixed with canal water in appropriate proportions, reduce residual alkalinity to safe limits.

The general rule for blending saline water with canal water should be that the blended water supplies should be within the threshold salinity tolerance rating of the more sensitive crops grown in the cropping system.

Blended Benefits

The strategy of using tanks for blending surface waters with alkali groundwater to irrigate soils has many benefits.

- Dilution of RSC makes the blended water safe for irrigation.
- Added groundwater provides additional head to the stored water for faster flow in the fields.
- Irrigation time is reduced.
- Blended water supplies make additional irrigation water available during crop season to improve yields.
- A variety of fish that feed at different depths can be grown in the tanks.
- On-farm water storage tanks can help avoid night irrigation vis-a vis improve irrigation efficiency.

References

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