FIGHTING ADVERSITY

MANAGING SALINITY FOR SOIL HEALTH

Soil salinization is the third important chemical soil degradation. It develops because of relative preponderance of soluble and sparingly soluble salts of sodium, calcium, magnesium and potassium. Excess salts and inadequate soil-water movement and specific ions toxicities in these soils consequently impede ecosystem functions and limits crop performance. Rehabilitation of salt-affected soil (SAS) occupies a major focus in the current policies of the government in order to achieve land degradation neutrality and land restoration. These are relevant for Sustainable Development Goals (particularly SDG 15-Life and Land) of United Nations.

Shortage of freshwater, erratic rainfall pattern, rising temperature, sea level rise, intrusion of brackish water, expansion of irrigated agriculture and dependency on waste water use for irrigation cause huge salt-load in the farmland. Inappropriate drainage network promotes the risk of salinization/sodication and deterioration of soil physical condition. Several agro-technological options are recommended to mitigate the adverse effect of salinity. A package of practices of amendments application and salt-tolerant cultivars of major crops are available for neutralize alkalinity and reclaim sodicity and sustain crop production.

Salt affected soils and associated losses

In India, total 6.74 mha area is affected by soil salinization comprising 3.79 and 2.95 million ha sodic and saline soils, respectively. Uttar Pradesh (35.8%), Gujarat (14.4%), Maharashtra (11.2%) and Tamil Nadu (9.4%), Haryana (4.9%) and Punjab (4.0%) together share 80% of the total sodic soils in India. Soil salinity, intrusion of sea water, salinity associated with water-logging and groundwater irrigation salinity are distributed across 13 states. The largest area is in Gujarat (56.8%) followed by West Bengal (14.9%), Rajasthan (6.6%) and Maharashtra (6.2%). Presently, sodicity diminishes more than 11 million tonnes (MT) of produce valued at Rs 15,000 crore.

Salinity hampered more than 5.66 MT of produce annually, valued at Rs 8000 cores. State-wise crop production losses due to sodicity reveal that UP suffered annual production losses of 7.6 MT, followed by Gujarat at 2.1 MT. State-wise production losses due to salinity stand at Gujarat (2.7 MT) followed by Maharashtra (0.92 MT), West Bengal (0.89 MT) and Andhra Pradesh (0.40 MT).

Strategies for reclamation and soil health improvement

Rehabilitation of salt-affected soil is a requisite to meet the demand of food for a growing population. The reclamation of salt-affected soils is possible with greening underproductive or barren land. These soils are the outcome of specific drivers of chemical land degradation such as the climate, geology, hydrology, soil types and land management implemented in the area.

Reclamation status

Over the past few decades, chemical amelioration of sodic soils in the Indo-Gangetic regions of Punjab, Haryana and UP has been well standardized.

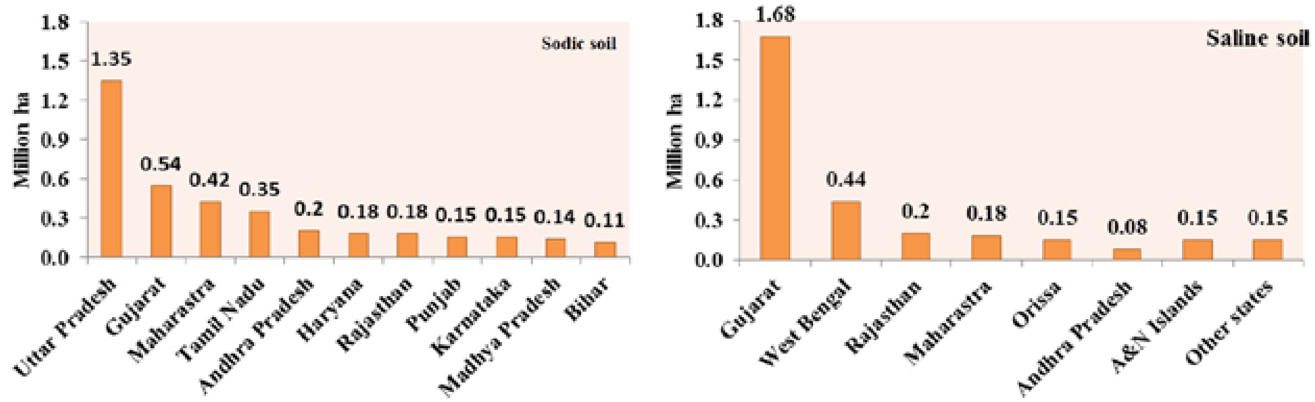

Fig. 1. State-wise distribution of sodic (a) and saline (b) soils

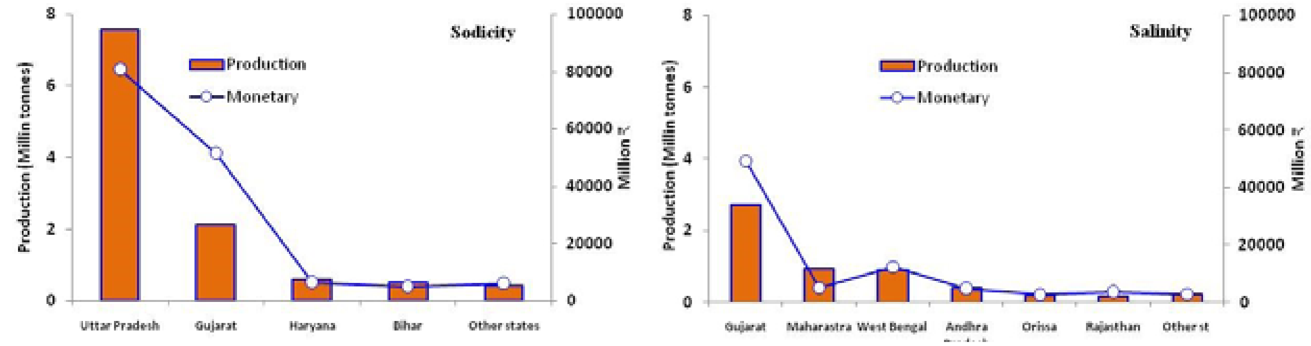

Fig. 2. State-wise annual production and monetary losses due to sodicity (a) and salinity (b)

With the support of World Bank, European Union and other developmental agencies, India has reclaimed 1.95 M ha of alkali lands. Several pilot scale manually laid subsurface drainage (SSD) projects, undertaken by ICAR-CSSRI during 1980s, have slowly paved the way for mechanically installed large projects in Haryana, Rajasthan, Maharashtra, Karnataka, Gujarat, Punjab and Andhra Pradesh. Implementation of large mechanically installed subsurface drainage projects has increased exponentially during the past 10 years with provision of government funding under schemes like CADA, RKVY and others. So far, about 66,500 ha waterlogged saline soils have been reclaimed with SSD in India.

Gypsum and alternate reclamation technology

Mineral gypsum, inorganic sulphur, press mud, acids, acidformers, phosphogypsum, fly ash, pyrites, aluminium chloride, bio-augmented material with gypsum etc. are generally recommended for reclaiming soil sodicity. If irrigation water quality is safe for soil and crop, then reclamation of soil sodicity is largely a one-time investment for sustaining production. Rice-based cropping cycle reaches its productivity potential level in nearly three years from reclamation. For managing incipient sodicity develops as a consequence of alkali water irrigation, application of gypsum or other amendment are needed at regular interval. The gypsum recommendation is advocated when RSC (residual sodium carbonate) of irrigation water exceeded 2.5 me L-1. The net present worth (NPW) of gypsum technology is averagely estimated to be 52,000/ha with benefit cost ratio (BC) of 1.43 and internal rate of return (IRR) of 25% of the technology. The technology

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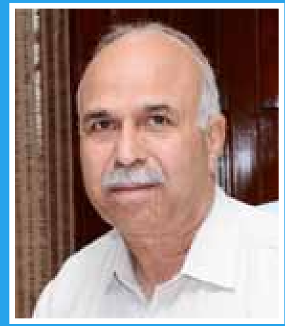

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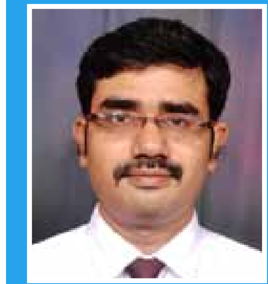

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Plate 2. Reclamation technologies for rehabilitation of salt-affected soils.

have been successfully implemented for improved soil health, increase resource use efficiency, raise farm income, minimize flood hazards and water logging and augment groundwater recharge.

Calcareous sodic soils are recommended for reclamation through application of elemental sulphur. However, elemental S must first be oxidized to sulphuric acid by soil microorganisms before they are available for reaction. Further, conjunctive application of sulphur and gypsum in 1:1 ratio significantly reduced the exchangeable sodium. Application of organic materials (city waste compost, gypsum enrich compost, sulphur rich compost, by product of sugarcane industry press mud) with conjunctive doses with gypsum requirement decrease the precipitation of Ca and carbonates, increase removal of Na in drainage waters, decrease soil pH and exchangeable sodium and improve crop yield.

Agronomic practices for saline soil

Leaching with good quality water (seasonal rain, canal or underground-water) to remove excess salts below the root zone is accomplished by ponding of water in well leveled field. The quantity of salts leached from soils depends on the quantity and quality of irrigation water and texture of soils. Sometime flushing with water is practiced to remove surface deposited salts in low permeable soils. Field scale salinity management needs proper soil and water crop management strategies to sustain cultivation in saline soil and with reduced risk of soil salinization and sustaining soil and environment quality. Properly leveled field, conservation tillage, mulching, conjunctive saline water irrigation in cycling and mixing mode, saline warer application avoiding physiological critical stages (germination and panicle initiation) and adoption of water efficient irrigation techniques (drip/sprinker) facilitating the washing of root zone salinity and sustaining crop production seems promising in productive utilization of salt-affected lands and use of saline water.

Subsurface drainage for inland saline soil with shallow water table

Sub-surface or surface drainage is a long-term solution for lowering water table and leaching of salts and to provide a favorable salt-balance in surface soil. Perforated corrugated PVC pipe covered with synthetic filter mechanically installed in proper plan below the effective rooting depth to lower down poor quality water table and leach excess salts and water by gravitational action or pressurized pump. The average cost of intervention and output per unit area is 60000/ ha in alluvial soils of North West India and 75000/ ha for heavy textured soils of Maharashtra and Karnataka. Due to notable increase in crop yields, the technology results in three-fold increase in farmers' income.

Land shaping technology

Land shaping techniques changes the landscape by developing raised and sunken beds by alternatively digging soil from one strip and putting it on the other. The modified land surface provides the scope for practicing integrated farming with diversified cropping round the year, creating irrigation facility, reducing salinity and improving drainage condition. The likely cost of intervention is about 99,000 per ha for soil excavation.

Bio-drainage

Excess soil water in shallow water table can be managed by facilitating physiological transpiration of tree. Waterlogging in saline soils with congestion of drainage problem can be managed by bio-drainage. This also provides additional benefit wood and associated ecological services. Benefits accrued by increased cropping intensity up to 300% vis-à-vis increase nutrient use efficiency, growing arable crops including pulses and oilseed, which otherwise is not possible on waterlogged soils and increased employment generation.

Crop management

Salinity and sodicity tolerance can be exploited for satisfactory yield under given levels of root zone salinity/ sodicity. Less water requiring crops like oilseed crops can tolerate higher levels of irrigation water salinity over salinity-sensitive pulses and vegetables. In coastal ecosystems, paddy is advised because of heavy downpour in kharif and facilitates leaching of soluble salts. Genotypic variability in different crops is now exploited to develop cultivars well suited to these abiotic stresses. A significant change in cropping landscape of salt affected areas is now because of the salt tolerant cultivars of rice, wheat, mustard and chickpea.

Table 1. Salt-tolerant varieties

Crop	Tolerant varieties	Abiotic stressors	
		Sodic, pH	Saline, EC(dS m-1)
Rice	CSR 27	9.9	10.0
	BasmatiCSR30*,	9.5	7.0
	CSR36*	9.9	11.0
	CSR43	10.0	7.0
Wheat	KRL1-4,KRL 19	9.3	7.0
	KRL210	9.3	6.0
	KRL283	9.3	
Indian mustard	CS56	9.3	9.0
(Raya)	CS58, CSR604*	9.5	12.0
Gram	KarnalChana 1	9.0	6.0
Sugarbeet	Ramonskaaya 06, MariboResistapoly	9.5–10	6.5
Sugarcane	Co453, Co1341	9.0	10.0

Way forward

Mineral gypsum is easily available, cheaper and easy to handle. It is the most common amendment for sodic soils. Gypsum consumption in country is rising with rapid infrastructure developments. The agriculture sector is facing issues of low availability and inferior quality of agricultural grade gypsum. Other alternate sources like phospho-gypsum, pyrites, pressmud and distillery spent wash are also used in some areas for reclamation of sodic soils. Limited availability, slow rate of reclamation and associated environmental hazards limit their application as substitute for gypsum. Recent developments in material science have led to the development of some formulations like polymers, nano-materials, acidified biochars, elemental sulphur, sulphurus acid generator and flue gas desulphurization gypsum (FGDG) having potential for replacing gypsum as an amendment. In future, scientifically managed city wate compost can also supplement the sodic soil reclamation programme. Poor policy support for subsurface drainage technology is limiting the success of salinity management in the country. Development of the updated database of salt affected soils and groundwater and ensuring the public-private partnership through people's cooperation can accelerate the pace of inland salinity management in India.