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**ENHANCING PRODUCTIVITY OF SALT AFFECTED SOILS
THROUGH CROPS AND CROPPING SYSTEM**

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Abstract

The reclamation of salt affected soils needs the addition of soil amendment and enough water to leach down the soluble salts. The operations may also include other simple agronomic techniques to reclaim soils and to know the crops and varieties that may be grown and other management practices which may be followed on such soils (Khan, 2001). The choice of crops to be grown during reclamation of salt affected soils is very important to obtain acceptable yields. This also decides cropping systems as well as favorable diversification for early reclamation, desirable yield and to meet the other requirements of farm families. In any salt affected soils, the following three measures are adopted for reclamation and sustaining the higher productivity of reclaimed soils.

1. Suitable choice of crops, forestry and tree species
2. Suitable choice of cropping and agro forestry system.
3. Other measures to sustain the productivity of reclaimed soils.

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1. CHOICE OF CROPS IN SALT AFFECTED SOILS

In salt affected soils for early reclamation and to get higher yield from initial year, the tolerant crop should be grown, followed by semi-tolerant crops. When land is properly reclaimed, the sensitive crops may also be taken.

a. Choice of Crops in Sodic Soil: In sodic soils, four types of crops may be selected according to grade of sodicity.

i. Tolerant crops: These crops can be grown when soil sodicity or alkalinity is > 50 ESP level. The yield level is 50% of the maximum > 50 ESP. They should be grown during initial years of reclamation. These are rice, *sesbania*, sugar beet, and barley. Besides to these, karnal grass, rodes grass, para grass or barmuda grass may also be grown for fodder purpose.

ii. Moderately tolerant crops: These crops can be grown with 50% of maximum yield at ESP level of 30-50 but give good yield in between 15-30 ESP. They should be grown after rice. Barseem, wheat, mustard, sunflower, sorghum, pearl millet, and turnip are major crops besides the fodder crops like oat and lucern.

iii. Semi-sensitive crops: The crops whose 50% yield loss is occurred when grown in 20-30 ESP level but do well in 5-15 ESP range are called semi-sensitive crops. Linseed, groundnut, garlic, onion and jowar are such semi-sensitive crops. They should be grown after 2-3 years of reclamation when ESP levels go to 15-30 range.

iv. Sensitive Crops: The crops whose yield is reduced to 50% in between 5-15 ESP level are called sensitive crops. They should be grown only after complete reclamation. Mostly pulses come under this group. Major crops are gram, pea, lentil, mung, soybean, maize and sesame.

2. CHOICE OF CROPPING / FORESTRY SYSTEM IN SODIC SOILS

a. Choice of Forestry Species in Sodic Soils: For sodic soils, the suitable forestry tree species are teak, sisham, siris, arjun, mahua, eucalyptus, semel, casurina, subabul and Australian babul. Species like arjun, casurina and subabul can be grown with good growth upto pH 10.0. Sesame does very well in Bihar. Details are given in Table 1.

Table 1: Relative tolerance of tree species to soil alkalinity.

Average pH	Fuel wood/timber species	Fruit trees
More than 10.0	<i>Prosopis spp.</i> <i>Acacia nilotica</i> <i>Casuarina equisetifolia</i> <i>Tamarix articulata</i>	<i>Archaras japota</i>
9 to 10	<i>Terminalia arjuna</i> <i>Albizzia lebbek</i> <i>Pongamia pinnata</i> <i>Sesbania Sesaban</i> <i>Eucalyptus tereticomis</i> <i>Cassia Siamea</i> <i>Pithecellobium duice</i>	<i>Punica granatum</i> <i>Zizyphus mauritiana</i> <i>Sapindus laurifolius</i> <i>Emblica laurifolius</i> <i>Embica officinalis</i> <i>Carlssa carnandas</i> <i>Psidium guajava</i> <i>Phoenix dactylifera</i> <i>Aegle marmelos</i> <i>Prunus persica</i> <i>Syzgium cumini</i>
8.2 to 9.0	<i>Dalbergia sissoo</i> <i>Morus alba</i> <i>Grevillea robusta</i> <i>Azadirachta indica</i> <i>Tectona grandis</i> <i>Populus deltoids</i>	<i>Pyrus communis</i> <i>Vitis vinifera</i> <i>Mangifera indica</i>

b. Choice of Fruit Species in Sodic Soils: Some fruit tree species can be grown in sodic soils like ber, awla, guava, mahua, grape, karonda, sahtoot, jamun and phalsa. Some fruits species and their relative salt tolerance has been given in Table 1 and 2. Mango and litchi may be grown in north Bihar after pit reclamation.

Table 2. Some suitable fruit species and their relative salt tolerance

S.No.	Fruit	Species	Tolerance		Suitable variety
			PH	ESP	
1.	Awla	<i>Emblica officinalis</i>	9.5	40	Chakaiya, NA-7, NA-6
2.	Guava	<i>Psidium guajava</i>	9.30	30	Sardar (L-49)
3.	Ber	<i>Ziziphus mauritiana</i>	9.5	45	Banarasi, Karka, Ponda
4.	Bael	<i>Aegle Marmelos</i>	9.0	30	Narendra 5, Narendra 9
5.	Grape	<i>Vitis Vinifera</i>	9.0	30	Beauty Seed less, Perlette
6.	Karonda	<i>Carissa Carandas</i>	9.2	35	Narendra Selection

Source: Management of Sodic Soils through Plantation, NDUAT, Faizabad, India

c. Cropping System: Central Soil Salinity Research Institute, Karnal, India has recommended following three cropping systems for sodic soils during initial years during process of reclamation:

- i. Rice-wheat - *sesbania* (Green Manure)
- ii. Rice-Barseem- *sesbania* (Green Manure)
- iii. Rice-Mustard- *sesbania* (Green Manure)

During early three years, rice based cropping system must be adopted. According to the institute, the fast reclamation is realized under Rice-Barseem - *sesbania* (GM) followed by Rice-Mustard - *sesbania*. Slow reclamation has been found in Rice-Wheat - *Sesbania*. During winter season, barley may be grown after rice but *sesbania* green manuring must be followed in any case. *Sesbania* also improves the physical properties of soil and adds nitrogen to the soil (Khan et al., 2000).

d. Forestry System: Agro-forestry have three components viz. tree, field crops, and forage crops. Tree components are always included in any agro-forestry system. In sodic soils any of the above mentioned systems may be adopted.

- i. Forestry – Fruit system means growing of forest and fruit trees simultaneously.
- ii. Forestry – Fodder system means cultivation of forage/fodder crops with forestry trees.
- iii. Horti – Forage system means fruit species with forage crops.

Among all three forestry systems, fruit trees have been found most remunerative. In this system, the fruits are available after 4-5 years and growth of forestry species is also takes place at the same time. After a definite time, fuel wood and fodder are available by the system.

3. CHOICE OF CROPS IN INLAND SALINE SOIL

The selection of suitable crops and cropping sequences for saline soil is necessary as crop vary in their tolerance to salinity. The selection of first crop should be based upon the expected levels of soil salinity after initial reclamation measures.

a. Highly Tolerant Crops (EC 25-35 dS/m): These crops are preferred to grow in the early stage of reclamation as they are tolerant and can cope up well with soil salinity. Barley, rice (transplanted), cotton, sugarbeet, tobacco, safflower, taramica and karnal grass are highly salinity tolerant.

b. Medium Tolerant (EC 15-25): After undertaking reclamation through sub-surface drainage or leaching of excessive salt from the root zone, the subsequent improvement in soil is gradual. These crops are grown after highly tolerant crops. Sugarcane, mustard, rice (direct seeded), spinach, wheat, pearl millet, Para grass, Rhodas grass and Sudan grass are such crops.

c. Medium Sensitive (EC 10-15): Radish cowpea, broad bean, cabbage, cauliflower, gourds, tomato, sweet potato, sorghum, maize, millet barseem, vetch and clover are medium salt sensitive crops which can be grown at very mild level of salt.

d. Highly Sensitive (EC 7-10): Lentil mash, chickpea, beans, peas, carrot, onion, lemon, orange, grape, peach, plum, pear and apple are highly sensitive to saline soils.

e. Cropping Systems under Inland Saline Soils : Central Soil Salinity Research Institute, Karnal, India has found following cropping systems most remunerative in saline soils when sub-surface drainage was installed.

- i. Pearlmiller – Wheat
- ii. Pearl millet – Mustard
- iii. Sorghum (Fodder) – Wheat/Mustard

4. CHOICE OF TREE SPECIES FOR DIVERSIFICATION IN SALINE SOIL

Table 3. Relative tolerance of trees to Soil Salinity.

Tolerant (EC 25-35 dS/m)	<i>Tamarix troupil</i> , <i>T. articulata</i> , <i>Prosopis juliflora</i> , <i>Pithecellobium dulce</i> , <i>Parkinsonia aculeate</i> , <i>Acacia famesiana</i>
Moderately tolerant (EC 15-25)	<i>Callistemon lanceolatus</i> , <i>Acacia nilotica</i> , <i>A. Pennatula</i> , <i>A. tortillas</i> , <i>Casuarina glauca</i> , <i>B. glauca</i> , <i>C. obesa</i> , <i>C. glauca (FRI)</i> , <i>C. equisetifolia (FRI)</i> , <i>Eucalyptus camaldulensis</i> , <i>Leucaena leucocephala</i> , <i>Erescentia alata</i>
Moderately sensitive (EC 10-15)	<i>C.cunninghamiana (FRI)</i> , <i>A. cunninghamiana (Aust)</i> <i>E. tereticomis</i> , <i>Acacia aunculiformis</i> , <i>Terminsallia arjuna</i> , <i>Pongamia pinnata</i> , <i>Guazuma ulmifolia</i> , <i>Leucaena shannoni</i> , <i>Samanea saman</i> , <i>Albizia carbea</i> , <i>Senna atomaria</i>
Sensitive (EC 7-10)	<i>Syzygium cumini</i> , <i>S. fruticosum</i> , <i>Tamarindus indica</i> , <i>Sali spp.</i> , <i>Acacia deami</i> , <i>Albizia guachepele</i> , <i>Aleleia herbertsmithi</i> , <i>Caesalpinia</i> , <i>eriostachys</i> , <i>C.velutina</i> , <i>Haematoxylon brasiletto</i>

5. CHOICE OF CROPS IN COASTAL SALINE SOILS

Rice is a major crop in coastal saline soils where variety CSR-4 and Canning-7 have been found to withstand at high salinity (6-8 dS/m⁻¹) level. Fodder crops have also been found tolerant to soil salinity, water logging and drought. Other important possible crops for such conditions are: wheat, mesta, chilli, cotton, barley, sunflower, okra, and fodder maize. Their degree of tolerance is as according to other saline soils.

a. Choice of Cropping Systems in Coastal Saline Soils

i. Where irrigation water supply is not limiting factor

- Rice-Rice
- Rice- *sesbania*

ii. When irrigation water supply is limited

- Rice-Wheat /Barley /Cotton /Mesta
- Rice-Chili /Sunflower /Okra
- Rice-Fodder Maize

b. Diversification in Coastal Saline Soils: In coastal saline soils, growing of normal rice culture in kharif (wet season), along with fresh water fish (FWF) and vegetable (V) like brinjal or okra followed by brakish water acquaculture (BWF), during summer without rice have been found most remunerative (Table 4).

Table 4. Diversification in Coastal Saline Soil

Farming System	Total yield of rice (kg/ha)	Net Return (Rs./ha)	Soil Salinity
Rice	3000	2200	Fresh water culture
Rice + FWF + BWF + Vegetable	2440	8702	Irrigation water for BWF 22.5 - 34.8 cm

6. SUSTAINING HIGHER PRODUCTIVITY OF RECLAIMED SODIC SOILS

a. Maintaining Water Table Below the Root Zone of Crops: In sodic soils, presence of ground water table in crop root zone is very detrimental. It increases the sodium salts as well as ESP. Therefore, it should be maintained below root zone by following measures:

i. Use of ground water in irrigation: Water table goes below the crop root zone by large scale of ground water pumping.

ii. Proper care and maintenance of drainage system: Proper operation and maintenance of developed drainage system automatically maintains the ground water level. Regular maintenance of drainage system by farmers/user group reduces the possibility of reoccurrence of sodicity again.

iii. Large scale plantation: In sodic soils, maximum plantation of suitable tree species should be done. These tree always transpire the water taken from ground level. This lowers the shallow ground water table.

b. Enhancing the Land Efficiency for Drainage: Possibility of reoccurrence of sodicity is reduced through enhancing the capability of land drainage. For this, the following two measures may be adopted:

i. Drainage of useless stagnant water from field: Useless stagnant water in any part of field or nearby should be removed through proper land leveling and clean drainage channels regularly.

ii. Judicious crop water management: Field to field irrigation should be avoided and irrigation channel must be formed for irrigation. Proper land leveling is required for equal distribution of water in field. Excess irrigation above the recommended depth should not be done. The last border / basin / plot should be irrigated first following the first border/basin at last. Light and frequent irrigation is always desirable in sodic soils whose infiltration rate is very poor.

c. Continuous Cropping: Initially sodic soils are very poor in organic carbon. There is fast depletion of organic carbon and humus if soil is left fallow. Hence, sodicity (sodium salts) starts coming above the surface and consequently the physico chemical and biological properties are deteriorated and soil again turned to sodic conditions. Therefore, the following measures are required to overcome with this problem:

- i. Continuous cropping
- ii. Use of FYM or compost as far as possible
- iii. Green manuring once in three years
- iv. Balance use of macro and micro-nutrients

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