

Farmer's participatory sodic soil reclamation programme

improved livelihood of resource poor farmers

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Land degradation due to the accumulation of salts in the soil is an alarming threat to agricultural productivity and sustainability, particularly in arid and semiarid regions of the world. In India, about 6.73 million ha soils are salt affected which represents 2.1% of the geographical area of the country. Out of these, 2.8 million ha are sodic and mainly occur in the alluvial soils of the Indo-Gangetic plains (IGP) and a large proportion of these soils are cultivated by smallholder farmers, who rely on that piece of land to satisfy their food and feed needs. High pH and exchangeable sodium content, and presence of soluble carbonate and bicarbonate, not only adversely affect the physico-chemical properties of the soils, but also profoundly influence the soil biological conditions. There are many approaches to reclaim sodic soils like chemical reclamation and phytoremediation. Under chemical amelioration, gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) has been used most extensively but it is costly (US \$50/t) and beyond the reach of small and marginal farmers because it is require in large quantity (12-16 t/ha) which contributes about 60% of the total reclamation cost. Pressmud, a sugar industry by-product, is readily available and less expensive than gypsum is one organic amendment, which can be used to improve the physical, chemical and biological properties of sodic soils, because it contains sizable quantities of macro-and micro-nutrients, high calcium sulphate and organic matter contents.

Key words: Livelihood, Resource poor, Soil reclamation

GROWING of salt tolerant varieties with improved management practices specific for sodic soils, could become a great opportunity for improving soil health and crop productivity of sodic soils. In this context, our study hypothesized that the involvement of farmers in the reclamation of highly sodic soils with integration of organic and inorganic amendments combined with the cultivation of salt tolerant varieties will be more sustainable. In view of the above hypothesis, a village named Santaraha in Hardoi district of Uttar Pradesh was selected for farmer's participatory sodic soil reclamation programme. The average size of land holding was 0.62 ha and the majority of the farmers belong to

marginal category (Table 1). Crop production was an important activity contributing 68% of the total household income in the area.

The village had a total of 123 ha of agricultural land owned by 197 farmers. Out of 123 ha total land in the village, about 74 ha belonging to 94 farmers had good soils (pH < 8.5 and exchangeable sodium percentage (ESP) 15) put under rice-wheat cropping system, whilst 49 ha degraded sodic soils, belonging to 103 farmers was uncultivated barren sodic lands with varying sodicity levels from pH 8.5 to 9.8 and ESP 15 to 70 (Table 2).

For sustainable reclamation, a demand responsive approach involving beneficiaries as prime

actors in survey, planning, implementation, monitoring and operationalization was adopted. Before the start of reclamation process, the farmers were made aware about the different activities and advantages of the project. They were informed about the importance of their co-operation in achieving the desired results. The team of scientists from CSSRI, Regional Research Station, Lucknow; Project Manager, Uttar Pradesh Bhumi Sudhar Nigam (UPBSN), and officials from DSCL Sugar, Hardoi visited the site and collected information on socio-economic condition, status of agriculture, infrastructure in the village and identified problems in reclamation and expectation of the



Table 1. Socio-economic profile of the selected village

Particular	Percentage/ value
<i>General information</i>	
Family size (No.)	7
Literary level (%)	40
Age (years)	48
Average farm size (ha)	0.62
Annual rainfall (mm)	629-818
Temperature (°C)	4-44
<i>Classification of farm holdings (%)</i>	
Marginal (<1.0 ha)	84
Small (1-2 ha)	16
Medium (>2-10 ha)	0
Large (>10 ha)	0
<i>Source of family income (%)</i>	
Crop production	68
Livestock	2
Service	1
Business	2
Others	27

Source: Thimappa *et al.* (2015)

farmers from the reclamation agencies involved.

The farmers were also apprised about the role and responsibilities to be shared by them. After collecting all the basic information, the reclamation process started in the month of April 2011. To follow the proper reclamation protocol, on-farm development works like bunding, field drains, irrigation channels, levelling and construction of link drain were initiated in farmers participatory mode. Land owners were asked to collect soil samples

Table 2. Categorization of land holdings under different sodicity classes in Santaraha village

Soil category	pH ₂	ESP	Area (ha)	No. of farmers	Area (%)	Land use
Normal soil	<8.5	<15	74.1	94	60.3	Rice-wheat
Slightly sodic (S ₁)	8.5-9.2	15-25	8.2	17	6.6	Only rice
Moderately sodic (S ₂)	9.2-9.6	25-45	6.4	18	5.2	Fallow
Sodic (S ₃)	9.6-10.0	45-75	8.9	40	7.2	Fallow
Severely sodic (S ₄)	10.0-10.4	75-85	25.6	28	20.8	Fallow
Total			123.1	197	100.0	

pH₂, soil pH in 1:2 soil: water suspension; ESP, exchangeable sodium percentage

from each plot after training by the CSSRI scientists and staff. To ensure water availability for leaching of salts as well as irrigating crops, one tube well was established at each 4.0 ha land stretch. The soil analysis results revealed that the pH range 8.5 to 10.1 and the gypsum requirement (GR) from 8.2 to 14.8 Mg/ha. Based on the results of laboratory analysis, gypsum was provided to the farmers @ 25% of estimated GR value. Agriculture grade mineral gypsum containing S (16.1%), Ca (18.3%), Mg (0.04%), and Na (0.18%) was applied in the month of June 2012 and mixed uniformly in the top soil (0-15 cm).

After application and mixing of gypsum, fields were ponded about 10 cm water for at least 10 days to displace the reaction product of Ca-Na exchange down to the root zone. After proper leaching of salts, pressmud collected from DSCL Sugar company containing S (0.23%), Ca (11%), Mg (1.65%),

total C (26%), total N (1.33%), total P (1.08%) and total K (0.53%) was broadcasted uniformly @ 10 t/ha and mixed in to the top soil. During this reclamation process, farmers share substantial amount of cost. All the initial pre-reclamation activities were managed by the farmers on their own cost. They also shared the cost of amendments and inputs. Seed of salt tolerant variety of rice 'CSR 36' was provided by the Central Soil Salinity Research Institute (CSSRI), Regional Research Station, Lucknow. Thirty-day-old seedlings of the salt tolerant rice variety 'CSR 36' were transplanted in July and improved management practices developed for sodic soils were followed.

The rice crop was harvested at physiological maturity when 80% of all panicles were yellowish in colour with an average yield of 2.82 Mg/ha. After harvesting of rice, salt tolerant variety of wheat 'KRL 19' was sown in November and harvested in April with an average yield of 1.15 Mg/ha. In order to improve the soil organic carbon content as sodic soils are deficient in organic carbon, *Sesbania* seed was provided to the farmers after harvesting of wheat and it sown in May for green manuring and turned into the field after 40 days. A crop rotation of paddy-wheat-green manure was followed for another two years of reclamation which resulted with an average yield of 3.52 and 3.91 Mg/ha of rice and 1.36 and 1.93 Mg/ha of wheat. The economic analysis of the reclamation technology was done. The variable costs were calculated based on the quantity of gypsum and pressmud applied to each field. The prevailing market rates of gypsum and pressmud during 2011-12 were US\$ 66.2 and 9.1/Mg, respectively. Other



Cluster of 49 ha sodic soil in village Santaraha



Mixing of gypsum in the surface layer



Ponding of water for leaching of salts

operational expenses included bunding @ US\$ 47.3/ha, leveling @ US\$ 243.6/ha, leaching @ US\$ 91.0/ha, mixing of gypsum and pressmud @ US\$ 16.4/ha, and installation of tube wells @ US\$ 48.0/ha. The average reclamation cost was \$1086/ha. Total costs of production in the initial year (2011-12) were significantly higher than in subsequent years, because it included full reclamation costs. The gross returns that was calculated on the basis of minimum support price of rice and wheat and the prevailing market rate for rice and wheat straw during 2011-12, 2012-13 and 2013-14 was \$1253.41, 1464.56 and 1666.97/ha. The net return during first year was negative due to addition of reclamation cost. However, in 2012-13, net returns increased remarkably because the high reclamation expenditures occurred only in 2011-12. A further

increase in net returns occurred in 2013-14.

Soil sodicity indicators like pH, ESP and SOC indicating that the application of reduced dose of gypsum at 25% GR with 10 t/ha pressmud followed by cultivation of salt tolerant varieties of rice and wheat have considerable improvement over the initial soil

characteristics. The soil pH reduced from 9.2 to 8.5, 9.6 to 8.5, 10.0 to 9.2 and 10.4 to 9.4 and, correspondingly, increased SOC from 0.21% to 0.32%, 0.12% to 0.26%, 0.08% to 0.16% and 0.08% to 0.14%. Compared with pre reclamation period, addition of amendments reduced ESP values by 52.94, 58.62, 62.8 and 56.18% in

Table 3. Impact of integrated approach of sodic soil reclamation on soil health

Sodicity indicator parameters	Slightly sodic (S ₁)	Moderately sodic (S ₂)	Sodic (S ₃)	Severely sodic (S ₄)
<i>Pre reclamation period (2011-12)</i>				
pH ₂	9.2	9.6	10.0	10.4
ESP	34	58	78	89
SOC (%)	0.21	0.12	0.08	0.08
<i>Post reclamation period (2013-14)</i>				
pH	8.5	8.5	9.2	9.4
ESP	16	24	29	39
SOC (%)	0.32	0.26	0.16	0.14

pH₂, pH in soil and water suspension ratio of 1:2; ESP, exchangeable sodium percentage; SOC, soil organic carbon



Transplanting of rice in treated fields



Performance of rice crop after reclamation



Table 4. Average yield (t/ha) of rice and wheat pre- and post-reclamation in the selected area

Year	Soil sodicity class				
	Normal	Slightly sodic	Moderately sodic	Sodic	Severely sodic
Rice					
<i>Pre-reclamation period</i>					
2009-2010	4.81	2.92	1.21	0	0
2010-2011	4.94	2.98	1.25	0	0
2011-2012	4.86	2.95	1.20	0	0
Average	4.87	2.95	1.22	0	0
Yield loss (%)	-	39.43	74.95	100	100
<i>Post reclamation period</i>					
2011-2012	5.10	4.83	4.38	3.87	2.79
2012-2013	5.23	5.12	4.73	4.54	3.10
2013-2014	5.32	5.04	4.86	4.86	3.23
Average	5.21	4.99	4.65	4.42	3.04
Yield loss (%)	-	4.35	10.74	15.16	41.65
Wheat					
<i>Pre-reclamation period</i>					
2009-2010	3.57	2.76	1.23	0	0
2010-2011	3.70	2.85	1.41	0	0
2011-2012	3.67	2.84	1.62	0	0
Average	3.65	2.82	1.42	0	0
Yield loss (%)	-	22.74	61.09	100	100
<i>Post reclamation period</i>					
2011-2012	3.67	3.13	2.76	2.10	1.63
2012-2013	3.81	3.43	3.02	2.63	1.82
2013-14	3.84	3.53	3.12	2.72	2.10
Average	3.77	3.36	2.96	2.48	1.85
Yield loss (%)	-	10.87	21.48	34.21	50.92

slightly sodic, moderately sodic, sodic and severely sodic land categories, respectively, after three years of reclamation (Table 3).

After three years of reclamation, all uncultivated lands reported before initiating the reclamation were put under cultivation. The rice yield declined in slightly sodic and

moderately sodic soils indicating 39.43 and 74.95%, respectively. However, yield reduction in sodic and severely sodic soil was 100% because there was no crop at this sodicity level. After reclamation, the yield loss over the normal soil reduced drastically. Wheat yield loss during pre reclamation in slightly

sodic and moderately sodic soils were 22.74 and 61.09%, respectively whereas, at sodic and severely sodic soils there was no crop. After post reclamation, yield loss at slightly sodic, moderately sodic, sodic and severely sodic soils reduced to the levels of 10.87, 21.84, 34.21 and 50.92% over the normal soils (Table 3).

During first year of reclamation, positive net returns were observed only for slightly sodic soils. With increasing levels of soil sodicity, the net return in the first year became increasingly negative. In 2012-13, net returns increased remarkably, because the high reclamation expenditures occurred only in 2011-12. A further increase in net returns occurred in 2013-14 (Fig. 1).

This shows that the crop yield gap and income loss were substantially reduced after reclamation due to reduction in the soil sodicity level and land became suitable for crop production. Several efforts have been made by the government agencies to reclaim salt affected soils and bring them under productive use but still, a large part of agricultural land is abandoned in India due to severe sodicity related problems. These lands need to be reclaimed through farmer's participatory approach following integration of gypsum, pressmud and salt tolerant varieties a cost effective technology for a faster and sustainable reclamation and to improve land productivity and farm income of resource poor farmers. The technology has the potential to reduce the reclamation cost remarkably, making it easier for resource poor farmer to adopt the practice. This would save the amount of chemical amendments needed that can further contribute to reclaim an even larger area. It is also concluded that the participatory reclamation and management approach is highly relevant and effective to ensure sustainable reclamation of sodic soils.

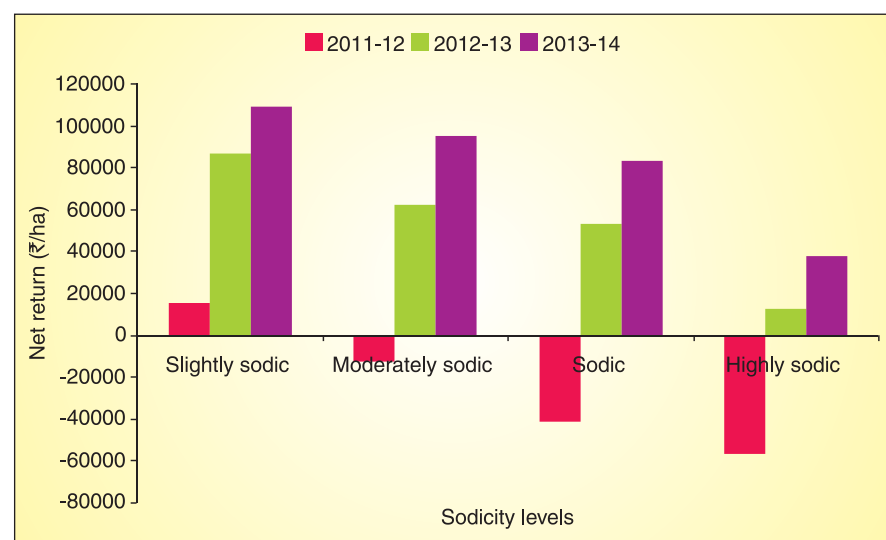


Fig 1. Net returns from rice farming over a three year period of reclamation

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