Interventions of Sodic Soil Reclamation Technologies and Constraints in their Adoption

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ABSTRACT

On farm participatory trials were initiated in Galwa command area in North-Eastern part of Rajasthan state of India. The command area was severely affected by sodicity due to indiscriminate use of sodic ground water. Before initiation of trails, a survey was conducted to evaluate farmers' response to land reclamation and to identify the constraints in adoption of reclamation technology. Out of 64 farmers surveyed, 34.4% knew the sodic soil reclamation technology, 44 farmers had not adopted any practice of sodic soil reclamation. Principal reasons of non-adoption of land reclamation was lack of availability of good quality water (27.3% farmers), while, other factors responsible for lack of response to technology were lack of risk bearing capacity, undulated topography, fragmented holdings, lack of investment power and knowledge of reclamation and limited availability of gypsum. After interventions for sodic soil reclamation, maximum and significantly higher mean yields of 4.69 t ha-1 grain and 5.07 t ha-1 stover of wheat and 2.61 t ha-1 grain and 11. 57 t ha-1 stover of pearlmillet was obtained with deep tillage in summer along with gypsum application @ 50% GR, green manuring and FYM @ 10 t ha-1 compare with other treatments, whereas non-significant difference was observed between deep tillage in summer along with gypsum application @ 25% GR, green manuring and FYM @ 10 t ha-1 and GR-50% along with green manuring and FYM @ 10 t ha-1 treatment. Treatment of deep tillage in summer along with GR-50%, green manuring and FYM @ 10 t ha-1 resulted in maximum reduction of pH and soil sodicity, improvement in infiltration rate and increase in available N, P, K and micronutrients.

Key words: *Pearlmillet; Wheat; Sodic soil; Constraints of reclamation; Soil properties;*

Salt affected soils are an important ecological entity in India and around 8.09 million ha is affected with menace of salinity in different climatic regions. Of this, 1.183 million ha area is in Rajasthan alone where soil reclamation programme is less effective as ground-water is of poor quality. As regards to underground water quality in Rajasthan state, only 16% is good, 16% marginal and 68% is of poor quality. Further, under poor quality water category, distribution of saline, sodic and saline sodic waters are about 16, 35 and 49%, respectively (*Sen, 2003*). Due to unavailability of good quality water for irrigation, use of poor quality under-ground water for irrigation has deteriorated the soil properties and reduced crop yields. Rajasthan state has developed several water projects for irrigation and drinking purposes. Galwa, Moti and Mansi dams for rain water conservation were developed in Tonk district. These dams are used to supply irrigation water through canals at critical stages of crops. Expansion of irrigation facilities through inter-basin transfer of water has created problems in different command areas through out the country, either in the form of water-logging, or a combination of water-logging and salinity in different irrigation commands. Moreover, sodicity problem in command areas is created due to indiscriminate irrigation with sodic under-ground water, as several times canals fail to supply irrigation water when needed. Further, undulated topography, low rainfall and high evaporation rate have also contributed to salt accumulation, deterioration of soil condition and low crop-yields. It calls for management of such soils to improve their physico-chemical condition for attaining higher sustainable crop production in command areas. The present study of farmers' participatory research was accordingly carried to study the constraints on adoption and interventions of sodic soil reclamation technologies on pearlmillet - wheat crop sequence in canal command area.

METHODOLOGY

The study was carried out in Tonk district situated in Nouth-Eastern part of Rajasthan state of India located at 23^0 3'- 30^0 12' N latitude and 69^0 30'- 78^0 17' E longitude. On-farm trails were initiated in Galwa command area of Uniara panchayat samiti of Tonk district of Rajasthan. During the initial phase of the project, a survey was conducted on sixty four farmers of two selected villages to study their response to sodic soil reclamation and identify the constraints on adoption of reclamation technology. Simultaneously, soil samples were also collected and analyzed for physico-chemical properties. The soils of selected fields were deficient in organic carbon (1.9g kg^{-1}), available N (147kg ha^{-1}), P (10.39 kg ha^{-1}) and Zn (0.44mg kg^{-1}), but medium in available K (237kg ha^{-1}). Available Cu, Fe and Mn contents were above the critical limit. Five representative farmers were selected for on farm participatory trials. The selected soil of farmers' field was sandy loam in texture and classified as Ustifluvents. The selected interventions for soil reclamation were as follows: T_1: farmer's practice (control), T_2: gypsum application as per gypsum requirement (GR) 25% + green manuring (GM), T_3: GR-50% + GM, T_4: GR-25% + GM + farm yard manure (FYM) @ 10 t ha^{-1}, T_5: GR-50% + GM + FYM @ 10 t ha^{-1}, T_6: deep tillage (DP) + GR-25% + GM + FYM @ 10 t ha^{-1} and T_7: GR-50% + DP + GM + FYM @ 10 t ha^{-1}. These seven interventions were applied only in first year from 28th June to 2nd July in five locations in randomized complete block design (RCBD). The experimental crop was wheat in *Rabi* season and pearlmillet grown in coming *Kharif* season. The experimental fields were divided in to seven sub plots, each having 500 m^2 area with 0.30m high bunds for conservation of rain water. Before making plots, field-leveling and deep tillage up to 24 cm was done by using disc plough during last week of May to first week of June (summer season). The sesbania seed was sown after application of gypsum as per treatment. The gypsum requirement varied from 3.75 to 5.46 t ha^{-1} as per sodicity level. The recommended packages of practices were followed during all the years as given in Table 1. The sesbania crop for green manuring was incorporated in to soil by harrowing after 50 days. The total rainfall received during the experimentation period was 451 and 506 mm in 2006-07 and 2007-08, respectively. As per availability of irrigation water from canal, pre irrigation, crown root, tillering and booting stage irrigations were given by canal (good quality) water and only at milking stage, irrigation were given by under-ground (sodic) water during 2006-07, while during 2007-08 irrigation in wheat crop with canal water. The composition of sodic irrigation water had EC - 0.67dS m^{-1}, RSC - 9.0m.e. L^{-1}, SAR - 14.7 and canal water EC - 0.25dS m^{-1}, RSC - 0.80m.e. L^{-1}, SAR - 0.92 was used for irrigation.

After harvest of wheat crop, soil samples were taken from 0-0.30m soil layer with an auger 4 cm in diameter. The soil samples were air dried and ground to pass through a 2 mm sieve. Soil pH, electrical conductivity (1:2 soil water ratio) and exchangeable sodium of soil were determined by using pH meter, conductivity bridge and flame photometer, respectively. The exchangeable sodium percentage was determined as per *Richards* (*1954*). Organic carbon, available N, P, K and micronutrients were determined by Kjeltec-II

Table 1. Details of experimental operations

Operation	Sesbania	Pearl millet	Wheat
Date of sowing	June 28 to July 2,	July 2-7	Nov. 15-22
Variety	Local	HHB-67	Raj-3765
Line to line spacing (cm)	15	20	15
Seed rate (kg ha^{-1})	40	20	100
N application (kg ha^{-1}) through urea	Nil	60	90
P_2O_5 application (kg ha^{-1}) through diammonium phosphate	Nil	60	60
Zn application (kg ha^{-1}) through Zinc sulphate	Nil	-	05
Pre-sowing irrigation (70mm)	First monsoonal rain	First monsoonal rain	01
Post-sowing irrigation (50mm)	Rain fed	Rain fed	4
Date of harvest	24-28th August*	1-9th October	6-12th April

* ploughing for green manuring by harrowing

auto analyzer, Olsen P, NH4OAc-extractable K and DTPA extraction using atomic adsorption spectrophotometer (*Jackson, 1973*), respectively. Infiltration rate after harvest of wheat from each treatment in each year were measured in situ by double ring infiltrometer method and measurement of soil bulk density using core sampler (0.12 m diameter and 0.15 m length).

RESULTS AND DISCUSSION

Knowledge and constraints on adoption of sodic soil reclamation technology: Primary survey was conducted about knowledge and adoption of sodic soil reclamation technology by 64 farmers' families of two selected villages of experimental area. The recommended practices of sodic soil reclamation were leveling of field, bunding for rain water conservation to facilitate leaching of salts, gypsum application @ 50% of gypsum requirement and green manuring. Out of 64 farmers in surveyed villages, about 14.1 per cent farmers used FYM for sodic soil reclamation, 9.4% field bunding for rain water conservation, 4.7% application of gypsum without knowing gypsum requirement and only 3.1 per cent used gypsum without knowing gypsum requirement along with FYM and conserve rain water (Table 2). Out of 64 farmers, 44 farmers had not adopted any practice of sodic soil reclamation. Main reason of non-adoption of land reclamation as stated by 27.3 per cent farmers was lack of availability of good quality irrigation water, and have poor quality of underground water (Table 3). Other factors responsible for poor adoption were lack of risk bearing capacity, undulated topography, fragmented holdings, lack of investment power and knowledge of soil reclamation and limited availability of gypsum.

Table 2. Prevailing practices of sodic soil reclamation adopted by farmers in the selected villages (N=64)

Practices	No.	%	Rank
Application of farm yard manure	09	14.1	I
Bunding for rain water conservation	06	09.4	II
Applications of gypsum without knowing gypsum requirement	03	04.7	III
Applications of gypsum without knowing gypsum requirement along with FYM and bunding of fields	02	03.1	IV
Did not know any practice	44	68.8	V

Table 3. Constraint on adoption of sodic soil reclamation practices by farmers in the selected villages (N=44)

Component	No.	%	Rank
Lack of availability of good quality water	12	27.3	I
Lack of risk bearing capacity	10	22.7	II
Undulated topography	07	15.9	III
Fragment holdings	06	13.6	IV
Lac of investment power	04	09.1	V
Lack of knowledge of soil reclamation	03	06.8	VI
Limited availability of gypsum	02	04.6	VII

Effect on yield: For sodic soil reclamation, application of gypsum as per GR @ 25% and 50% alone or in combination with green manuring, FYM @ 10 t ha^{-1} and deep tillage in summer were very effective and significantly improved the grain and stover yields of pearlmillet and wheat as compared to control (Table 4). Pooled yield indicated that the treatment of deep tillage in summer + GR-50% + green manuring and FYM @ 10 t ha-1 (T_7) was the best treatment as the highest mean yields of 2.61 and 11.57 t ha^{-1} of grain and stover, respectively, of pearlmillet and 4.69 and 5.07 t ha^{-1} of grain and stover, respectively, of wheat

Table 4. Response of levels of gypsum, deep tillage, green manuring and FYM on grain and stover yields of pearlmillet and wheat.

Treat ment	Pearl millet yield (tonnes ha^{-1})			Wheat yield (tonnes ha^{-1})		
	2007	2008	Mean	2007	2008	Mean
T1	1.05 (5.59)*	0.91 (3.49)	0.98 (4.54)	1.55 (1.97)	1.46 (2.29)	1.51 (2.13)
T2	1.72 (7.45)	1.82 (7.91)	1.77 (7.68)	2.97 (3.34)	3.20 (3.54)	3.09 (344)
T3	2.06 (9.06)	2.29 (9.39)	2.18 (9.23)	3.44 (3.90)	3.78 (4.29)	3.61 (4.10)
T4	1.97 (8.65)	2.17 (8.89)	2.07 (8.77)	3.35 (3.87)	3.45 (3.91)	3.40 (3.89)
T5	2.35 10.49)	246 (11.19)	2.41 (10.84)	4.03 (4.41)	4.18 (4.60)	4.11 (4.51)
T6	2.27 (10.10)	2.31 (10.65)	2.29 (10.38)	4.02 (4.55)	4.17 (4.68)	4.10 (4.62)
T7	2.50 (11.20)	2.71 (11.93)	2.61 (11.57)	4.46 (5.01)	4.91 (5.12)	4.69 (5.07)
CD at 5%	0.16 (1.05)	0.21 (1.19)	- -	0.21 (0.46)	0.19 (0.38)	- -

*Stover yield

was recorded. The lowest mean yield of 0.98 and 4.54 t ha^{-1} of grain and stover, respectively, of pearlmillet and 1.51 and 2.13 t ha^{-1} of grain and stover, respectively, of wheat was recorded with farmer's practice (T_1). The application of gypsum enhanced the availability of soluble calcium directly and indirectly through dissolution of native CaCO3. The calcium thus released displaced the Na+ from exchange complex and removal of soluble Na with anions (CO3= + HCO3-) through leaching reduced the pH of soil as well as improved the physico-chemical properties of soil. Addition of organic manure improved the physicochemical environment in soil and consequently, greater extraction of water and nutrients by plants from the soil. These results are in conformity with findings of *Singh et al., (2011)* and *Yaduvanshi and Sharma (2007)*. Non-significant difference was noticed between deep tillage in summer + GR-25% + green manuring + FYM @ 10 t ha^{-1} (T_6) and GR-50% + green manuring and + FYM @ 10 t ha^{-1} (T_5). Deep tillage was more effective in sandy loam soil which has low apparent field capacity and higher infiltration rate.

Effect on physico-chemical properties: Application of gypsum @ 25% or 50% GR alone or in combination with GM, FYM and deep tillage in summer significantly reduced the pH and ESP and increased the available N, P, K and micronutrients (Table 5). Maximum reduction noticed in pH was 1.14, ESP 21, bulk density 0.05 Mg m-3, and increase in organic carbon was 0.4 g kg^{-1} soil, available N 72 kg ha^{-1}, P 6.1 kg ha^{-1}, K 69 kg ha^{-1}, Zn 0.33 mg kg^{-1}, Fe 0.7 mg kg^{-1}, Cu 0.05 mg kg^{-1} and Mn 0.60 mg kg^{-1} with the treatment of deep tillage in summer along with GR-50%, green manuring and FYM @ 10 t ha^{-1}. Next highest reduction in pH was 0.92 and in ESP 19, bulk density 0.03 Mg m^{-3}, and increase in organic carbon 0.3 g kg^{-1}, available N 66 kg ha^{-1}, P 4.7 kg ha^{-1}, Zn 0.31 mg kg^{-1}, Fe 0.6 mg kg^{-1}, Cu 0.03 mg kg^{-1} and Mn 0.50 mg kg^{-1}, under the treatment GR-50% along with green manuring and FYM @ 10 t ha^{-1} (T_5) from control values of pH - 8.95, ESP - 32, organic carbon - 1.5g kg^{-1}, bulk density - 1.51 Mg m^{-3}, available N - 121 kg ha^{-1}, P - 10.7 kg ha^{-1}, K - 246 kg ha^{-1}, Zn - 0.43 mg kg^{-1}, Fe - 5.2 mg kg^{-1}, Cu - 0.28 mg kg^{-1} and Mn - 2.0 mg kg^{-1}, respectively. The treatment of deep tillage in summer along with GR-25%, green manuring and FYM @ 10 t ha^{-1} was as effective as T_6. Application of gypsum as per GR and organic manure reduced soil sodicity, improved physico-chemical properties and consequently improved availability of nutrients in soil (*Singh et al., 2011*).

Infiltration rate: At the end of Rabi crop during all the years, infiltration rate was measured in all the treatments (Table 5). The infiltration rate significantly increased with the application of gypsum @ 25% or 50% with green manuring only or along with FYM @ 10 t ha^{-1} and deep tillage in summer. Maximum infiltration rate 3.15 cm hr^{-1} was recorded with deep tillage in summer + GR-50% + green manuring + FYM @ 10t ha^{-1} followed by 2.85 cm hr^{-1} in the treatment of deep tillage in summer + GR-25% + green manuring + FYM @ 10 t ha^{-1} and 1.82 cm hr^{-1} with GR-50% + green manuring and FYM @ 10 t ha^{-1}, respectively. The application of gypsum to sodic soil has been reported to improve aggregate stability and consequently the infiltration rate (*Choudhary et al., 2006*).

Table 5. Response of gypsum, deep tillage, green manuring and FYM on physico-chemical properties after harvest of wheat (2 year mean)

Treatment	EC (dS m^{-1})	pH	ESP	OC (g kg^{-1})	BD (Mgm^{-3})	IR (cm hr^{-1})	Available nutrients						
							N	P	K	Zn	Fe	Cu	Mn
T1	0.53	8.95	32	1.5	1.51	0.32	121	10.7	246	0.43	5.2	0.28	2.0
T2	0.32	8.29	20	1.9	1.50	1.06	150	12.7	278	0.53	5.3	0.28	2.2
T3	0.33	8.02	16	1.4	1.48	1.23	173	13.4	286	0.67	5.5	0.29	2.3
T4	0.31	8.24	17	1.7	1.49	1.65	164	13.5	290	0.70	5.6	0.30	2.3
T5	0.34	8.03	13	1.8	1.48	1.82	187	15.4	294	0.74	5.8	0.31	2.5
T6	0.27	8.08	14	1.8	1.46	2.85	184	14.9	290	0.70	5.7	0.31	2.4
T7	0.28	7.81	11	1.9	1.46	3.15	193	16.8	315	0.76	5.9	0.33	2.6
CD at 5%	0.15	0.27	1.5	0.1	0.03	0.20	21	1.5	26	0.06	0.14	0.01	0.15

EC–electrical conductivity, ESP–exchangeable sodium percentage, OC–organic carbon, BD–bulk density, IR–infiltration rate, N, P and K in kg ha^{-1}, Zn, Fe, Cu and Mn in mg kg^{-1}

CONCLUSION

Primary survey indicated that only 34.4% farmers knew the recommended practices of sodic soil reclamation, whereas only 3.1% farmers used gypsum without knowing gypsum requirement along with application of FYM and did bunding of fields for rain water conservation, 4.7% used gypsum without knowing gypsum requirement, 9.4% did bunding of fields for rain water conservation and 14.1% used FYM. The grain and stover yields of pearlmillet and wheat was significantly improved by the addition of gypsum @ 25 and 50% GR with green manuring or along with FYM and deep tillage in summer. Similarly, an increase in content of organic carbon, available N, P, K and micronutrients, and a decrease in pH, ESP and bulk density of the soils was observed. Maximum grain and stover yield of pearlmillet and wheat was obtained with deep tillage in summer along with gypsum application @ 50% GR + green manuring + FYM @ 10 t ha^{-1} followed by non-significant difference was noticed between GR-50% + GM + FYM @ 10 t ha^{-1} and deep tillage in summer along with gypsum application @ 25% GR + green manuring + FYM @ 10 t ha^{-1}.

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