Impact of Sodic Soil Reclamation Technology : An assessment of On-Farm Trials

Y. P. Singh[1], S. V. S. Chauhan[2], H.C. Singh[3] and Sudhir Singh[4]

1. Programme Coordinator, 2. SMS (AE), KVK, Morena, MP, 3. Asstt. Prof. (Ag. Ext), COE (CSAUA&T) Etawah, 4. ARS (R.A.U.), Durgapura, Jaipur

Corresponding author e-mail: kvkmorena@rediffmail.com),

ABSTRACT

The ground water of north-eastern and southern parts of Rajasthan is having with problems of high content of carbonate, bicarbonate and sodium ions. Unavailability of good quality water for irrigation, numbers of farmers are using such problematic water for irrigation resulting in accumulation of ions and making soil unfit for cultivation. Amelioration of sodic effect of soil by deep tillage with gypsum requirement (GR)-50% and green manuring maximum improvement in the grain and straw yield was 179.5 and 149.7 % in wheat, 139.9 and 141.4 % in barley and 119.1 and 84.1 % in mustard, respectively. Next one was with the application of GR-50% with green manuring. Similar trend was followed for improvement in soil properties. Maximum net profit obtained by farmers' in case of using deep tillage with GR-50% and green manuring was Rs 13285/ha in wheat, Rs 10850/ha in barley and Rs 8190/ha in mustard followed by GR-50% with green manuring practice.

Key words: *Ground water; Carbonate; Bicarbonate; Sodium; Sodic effect; Gypsum; Green manuring;*

Sodic soil usually occurs in association with normal soils of arid and semi-arid regions of Rajasthan. The contributing factors for the formation of these soils are high evaporation, low and uneven rainfall, undulated topography, presence of salt at some layer in the soil and ground water with high rich sodium content, which is an important source of irrigation. Due to above factors sodic soil reclamation programme is less effective in arid and semi-arid region of Rajasthan. Leaching by good quality water is an important process executed after the application of gypsum to displace the reaction products of Ca-Na exchange down the root zone. Limited availability of good quality water resources for irrigation in Rajasthan forces the farmers to use under ground poor quality water resulting in increase of the salt affected area. Such type of sodic underground water is found to the extent of about 35% in Rajasthan. Similar quality of irrigation water found in other states of the country viz. Gujarat, Haryana, Punjab and U.P. is 28, 30, 54 and 39 % area affected, respectively *(Yadav and Kumar, 1994).*

METHODOLOGY

Soil survery of villages i.e. Pallai, Haripura, Jugalpura and Banasthali of Newai Panchayat Samiti of Tonk district was carried out and soil properties of selected field for reclamation in watershed area depicted in Table 1. Total surveyed area was 525 ha of different villages out this, 80 ha land (15.24%) was affected due to sodicity. The soil was sandy loam in texture and neutral to alkaline in reaction. In general, the soils were low in organic carbon, available N, P and Zn.

Table 1. Soil properties of selected fields for reclamation in watershed area

S. No.	Character	Ranges	Average
1.	pH_2	8.6-9.9	9.36
2.	EC_2(dS/m)	0.28-1.04	0.67
3.	ESP	22.5-58.8	39.8
4.	Organic Carbon (%)	0.12-0.64	0.19
5.	Calcium Carbonate (%)	0.18-0.99	0.38

The selected farmers for participatory on farm trials had grown mustard, wheat and barley and kept fallow in *kharif,* irrigated with ground water having RSC up to 12meq/litre with occasional application of gypsum. Two recommended practices were tested for reclamation of sodic soil viz. gypsum application as per GR-50% with green manuring and other one, deep tillage

before application of GR-50% with green manuring compared with farmers' practice. The reclamation programme was undertaken from May 2005. Before initiating reclamation programme, run off from surrounding area checked by preparing strong bunds and leveling at all the selected farmers' fields. The height of bund was 45 to 60cm for conservation of rainwater for gypsum dissolution. Each farmer's field divided in to three equal plot size. The routine tillage practice consisted up to 12cm deep and deep tillage with disc plough up to 20 to 25 cm in the month of May. Broadcasting of gypsum on soil surface and mixed in upper 10 to 12 cm soil depth using cultivator. In *kharif* season, the farmers cultivated dhaincha (*Sesbania aculeata*) for green manuring as per treatments. The crop of dhaincha mixed in soil (harrowing) after 45 to 50 days of sowing hastens the reclamation and also builds organic matter in soil. The total rainfall received during the year was 506 mm. During *rabi* season, wheat variety Raj-3077 (11 farmers' field), barley variety RD-2552 (8 farmers' field) and mustard variety BIO-902 (14 farmers' field) were grown following recommended package of practices. At the time of harvest, 5m x 5m size plots were randomly selected for each package. The statistical significance between the treatment means was tested following randomized block design. Grain and straw yield were recorded and the incremental cost benefit ratio (ICBR) and additional net return were calculated. Soil samples were also collected and analyzed for physico-chemical properties. The initial and after harvest of crops, soil samples were taken from 0 to 0.30 m 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 samples were determined using pH meter, conductivity bridge and flame photometer, respectively. The exchangeable sodium percentage was determined as per U.S.D.A. Hand book 60 (*Richards, 1954*). Organic carbon, available N, P, K were determined by *Walkley and Black (1934)*, Kjeltec-II auto analyzer, Olsen P, NH_4O Ac-extractable K, (*Jackson, 1973*), respectively.

RESULTS AND DISCUSSION

Improvement of soil properties : Surface soil samples were collected from individual farmer's field analysis of (pH), electrical conductivity (EC), exchangeable sodium percentage (ESP), organic carbon and available N, P, K after reclamation (before sowing of *rabi* crops) given in Table 2. As a result of rainfall the values of pH, EC and ESP significantly decreased slightly. The average pH of farmer's practice before sowing *rabi* crops was 8.81 and after GR-50% with green manuring practice pH value was decreased 0.40 unit (8.41), whereas maximum decreased 0.66 unit (8.15) due to deep tillage with GR-50% and green manuring practice. Reduction in EC and ESP was 0.04 ds/m and 10.3 in package of GR-50% and green manuring, whereas maximum reduction 0.12 ds/m and 13.1 with the package of deep tillage with GR-50% and green manuring practice from farmers' practice plots value of EC 0.43 ds/m and ESP 27.8, respectively.

The organic carbon of farmers' practice plots was recorded 0.21% and after application of GR-50% and green manuring practice the value of organic carbon recorded 0.26% and maximum organic carbon 0.29% due to deep tillage with GR-50% with green manuring practice. The availability of nitrogen, phosphorus and potash was significantly increased after application of GR-50% with green manuring practice were 216, 12.7 and 304 kg/ha and maximum values 225, 14.5 and 365 kg/ha due to deep tillage with GR-50% and green

Table 2. Effect of different practices on properties of sodic soil before sowing of *rabi* crops (mean values)

Soils properties	Control	GR-50% with green manuring	Deep tillage with GR-50% and green manuring	S Em±	CD at 5 %
pH_2	8.81	8.41	8.15	0.04	0.13
EC_2(dS/m)	0.43	0.39	0.31	0.03	0.09
ESP	27.8	17.5	14.7	2.11	6.42
Organic Carbon (%)	0.21	0.26	0.29	0.05	NS
Available N (kg/ha)	160	216	225	4.17	12.67
Available P (kg/ha)	9.5	12.7	14.5	1.08	3.29
Available K (kg/ha)	285	304	365	0.17	15.40

manuring practice compare with farmers' practice 160, 9.5 and 285 kg/ha, respectively. Application of gypsum as per GR and organic manure reduced soil sodicity, improved physico-chemical properties and consequent higher availability of nutrients in soil (*Minhas et al., 1995*). *Arora et al., (1991)* also reported that deep tillage improved the physical properties of soil.

Effect on yield and economics : Pooled results of 11 farmers' field (Table 3) indicated that grain and straw yield of wheat maximum significantly improved with deep tillage with GR-50% and green manuring was done followed by GR-50% with green manuring compared with farmers' practice. The increase in grain and straw yield of wheat was 132.8 and 110.1 % under the practice of GR-50% with green manuring and 179.5 and 149.7 % under deep tillage with GR-50% and green manuring practice. On an average, maximum additional grain and straw yield of wheat was 21.9 and 26.8 q/ha under deep tillage with GR-50% and green manuring plots over farmers' practice plots, respectively. Similarly, higher additional net return Rs 13285/ha and incremental cost benefit ratio (ICBR) 2.11 was recorded with deep tillage with GR-50% and green manuring practice was followed. However, net returns Rs 9160/ha and ICBR 1.73 with application of GR-50% and green manuring practice was obtained. The application of gypsum enhanced the availability of soluble calcium directly and indirectly through dissolution of native $CaCO_3$. The calcium thus released displaced the Na+ from exchange complex and removal of soluble Na with anions ($CO_3^{=}$ + HCO_3) through leaching reduced the pH of soil and improved the physico-chemical properties of soil. Addition of organic manure and farm waste improved the physicochemical environment in soil and

Table 3. Effect of different practices on yield of crops (mean values)

Treatment	Yield (q/ha)		Additional yield (q/ha)		Additional cost of inputs	Additional net return (Rs/ha)	ICBR
	Grain	Straw	Grain	Straw (Rs/ha)			
Wheat							
1. Control	12.2	17.9	-	-	-	-	-
2. GR-50% with green manuring	28.4	37.6	16.2	19.7	5310	9160	1:1.73
3. Deep tillage with GR-50% and green manuring	34.1	44.7	21.9	26.8	6310	13285	1:2.11
4. S Em±	0.35	0.69	-	-	-	-	-
5. CD at 5 %	1.37	2.72	-	-	-	-	-
Barley							
1. Control	15.8	16.2	-	-	-	-	-
2. GR-50% with green manuring	32.4	34.5	16.6	18.3	4885	7905	1:1.62
3. Deep tillage with GR-50% and green manuring	37.9	39.1	22.1	22.9	5885	10850	1:1.84
4. S Em±	0.97	0.34	-	-	-	-	-
5. CD at 5 %	3.83	1.21	-	-	-	-	-
Mustard							
1. Control	6.8	17.6	-	-	-	-	-
2. GR-50% with green manuring	12.9	8.4	6.1	10.8	5072	5660	1:1.12
3. Deep tillage with GR-50% and green Manuring	14.9	32.4	8.1	14.8	6072	8190	1:1.35
4. S Em±	0.49	0.14	-	-	-	-	-
5. CD at 5 %	1.94	0.54	-	-	-	-	-

Gypsum @ Rs 116/q (without subsidy in Rajasthan), dhaincha seed @ Rs 14/kg, ploughing rate by disk plough @ Rs 1000/ha, sale prince of wheat grain Rs 650/q, barley Rs 550/q, straw@ Rs 200/q and mustard seed @ Rs 1715/q and straw @ Rs 25/q

consequently, greater extraction of water and nutrients by plants from the soil. These results are in conformity with findings of *More (1994)* and *Yaduvanshi and Sharma (2007)*.

A perusal pooled data (Table 3) of 8 farmers' field reveals that grain and straw yield of barley significantly increased with both the practice of application of GR-50% with green manuring and other on practice of deep tillage with GR-50% with green manuring compared with farmers' practice. The increased in grain and straw yield of barley was 105.1 and 113.0 %, respectively in the practice of GR-50% with green manuring and 139.9 and 141.4 % under deep tillage plots with GR-50% and green manuring practice, respectively compared with farmers' practice. Similar findings were also reported by *Minhas (1995)* and *Yaduvanshi and Sharma (2007)* in case of wheat crop. On an average, maximum additional grain and straw yield of barley was 22.1 and 22.9 q/ha, respectively under deep tillage plots with GR-50% and green manuring, whereas 16.6 and 18.3 q/ha under GR-50% and green manuring practice compared with farmers' practice. Similarly, higher additional net return Rs 10850/ha and ICBR 1.84 was obtained under the package of deep tillage with GR-50% and green manuring followed by net return Rs 7905/ha and ICBR 1.62 with GR-50% with green manuring practice.

In case of mustard, pooled result of 14 farmers' field (Table 3) indicated that grain and straw yield significantly increased with both the treatment of GR-50% with green manuring and deep tillage with GR-50% and green manuring practice compared with farmers' practice. The increase in grain and straw yield of mustard was 89.7 and 61.4 % with GR-50% under green manuring practice and 119.1 and 84.1 % under deep tillage with GR-50% and green manuring practice compared with farmers' practice, respectively. *Pal and Phogat (2005)* also observed that deep tillage and gypsum significantly increased the yield of mustard in sandy loam soil. On an average, maximum additional grain and straw yield of mustard 8.1 and 14.8 q/ha under deep tillage plots with GR-50% and green manuring, whereas 6.1 and 10.8 q/ha under GR-50% with green manuring practice compared with farmer's practice. Similarly, higher additional net return Rs 8190/ha and ICBR 1.35 was obtained with deep tillage with GR-50% and green manuring plots followed by net return Rs 5660/ha and ICBR 1.12 under GR-50% and green manuring practice.

CONCLUSION

Study conducted on farmer's field indicates that the maximum grain and straw yield of wheat, barley and mustard was obtained when one deep tillage in summer with GR-50% and green manuring plots was done. GR-50% and green manuring was found to be next in order. Similarly trend in additional net return incremental cost benefit ratio of wheat, barley and mustard crops were found. As regards effect on soil properties, deep tillage in summer with GR-50% and green manuring practice was best followed by GR-50% with green manuring practice.

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