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Effect of fym & gypsum under sodic water irrigation on available nutrients in soil

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Abstract
An ongoing long-term field experiment established in 1994 under different vegetable cropping system established at the Vegetable Science research farm, CCS HAU, Hisar, India was selected to study the effects of sodic water irrigation, gypsum and farmyard manures on soil available nutrients in soil. The field was irrigated with high RSC (11.5 me/l) sodic water having three levels of gypsum (G_0,G_1,G_2) G_0 control,G_1=50 % neutralization of RSC,G_2 = 100% neutralization of RSC, as well as FYM (F_0, F_1, F_2) (F_0 = control, F_1= 10 tons/ha, F_2 =20 tons/ha) on a sandy loam Typic Ustochrept having 19.6 percent clay and 9.3 Cmol/kg cation exchange capacity in 0-15 cm layer. Results showed that the pH of soil very high under F_0G_0, and decreased with the use of FYM and gypsum as amendments, however reverse trend observed in Electrical conductivity. Increasing trend of all available nutrients was observed when FYM applied over no FYM application but with the application of gypsum, Available nutrients (N, P, S) content increased in soil but available K content decreased. These results indicate that the combined use of FYM and gypsum improved soil health and maintained the sustainability of the different vegetable cropping system.

Keywords: Soil health, available nutrients, chemical properties, sodic water, farmyard manures

Introduction
In arid and semi arid regions, irrigation water plays a vital role in crop production, where scarcity of good quality water is major problem. Groundwater surveys indicate that the poor quality waters being utilized for irrigation purposes in different states of India range between 32 and 84% of the total groundwater development (Choudhary 2007). The problem is particularly acute in north-western India where 40–60% of the groundwater show high incidence (30–50%) of residual alkalinity. In India, 3.6 Mha of the soil is adversely affected by sodicity of which 84,800 ha occurs in Haryana (Yadav *et al*. 2002) [30]. Furthermore, in Haryana on an average 55% of ground waters are brackish in nature and amongst the poor quality waters, proportion of the sodic, saline and saline-sodic waters is 18, 11 and 26%, respectively (Manchanda 1976) [13]. In south-western Haryana, sodic waters are maximum in Rewari, Mohindergarh districts followed by Bhiwani and Gurgaon where more than 70% of net irrigated area is covered by tube wells. The inadequate and un-assured supplies of good quality water have forced the farmers to use sodic ground waters for irrigating crops because they don’t have other option except to use the poor quality waters for irrigation. Continuous and Indiscriminate use of sodic water for irrigation deteriorates all the soil physico-chemical characteristics of soil causing nutritional disorder associated with high pH, EC, and exchangeable sodium percentage (ESP), but also modifies the quality of soil organic carbon.
Soil organic carbon (SOC) is the key contributor to soil productivity directly through the regulating the soil physical conditions as well as chemical and biological properties. To offset the harmful effects of sodic water, application of gypsum is a common practice. In addition, organic manures like farmyard manure (Minhas *et al*. 1996, Batra *et al*. 1997) [14, 3]. We, therefore, carried out a long-term field investigation to study the effect of sodic water irrigation in the soil, and how amendments (FYM and Gypsum) can lead to improvement in soil properties.

Material and Methods
Experimental site and treatments
The present long term field experiment was initiated in 1994 on vegetable research farm, department of Vegetable Crops of CCS Haryana Agricultural University,

Hisar is situated at 29°10' North latitude and 75°46' longitude at the mean elevation of 215.2 m, having a gentle slope towards south western direction. It has tropical monsoonal climate and is characterized as arid type of climate. Summers are very hot and the winter is usually cold and dry. Hot storms are common features of the area. The temperature generally fluctuated between 1.9°C (January) and 46°C (May) during the year. The normal annual rainfall is 330 mm which is unevenly distributed over the area 22 days. The soil of the experimental field was sandy loam, Typic Ustochrept having 19.6 percent clay and 9.3 C mol/kg CEC in depth of 0-15 cm layer. The initial physico-chemical properties of soil under different treatment are presented in table 1.The experimental treatments were laid out in randomized block design (RBD) having 3 levels of FYM(0, 10 and 20 t/ha represented as F_0, F_1 and F_2, respectively) and gypsum (0, 50 and 100% neutralization of RSC represented as G_0, G_1 and G_2, respectively). These were replicated thrice. Total 27 plots were irrigated with sodic water of the farm tube well having the ionic composition dominated by HCO^{-3} of Na^+ and thus having the values of EC, RSC and SAR of 2.4 dS/m, 11.5 me/l and 14 mmol/1 ½ respectively. The fertilizer in all plots was applied @ 125 kg N, 50 kg P_2O_5 and 100 kg K_2O per hectare in the plots of the uniform sizes of 3.0 m x 3.0 m. Nutrient composition of FYM used in the experiment containing organic carbon 38 %, N 1.20, P 0.97 and K 1.87 % and gypsum having 23.1% calcium and 18.6 % sulphur. Soil samples (0-15 cm) were collected after 20 years in the month of April from all the plots. Soil samples were air- dried ground and passed through sieve (2 mm) and analyzed by adopting standard procedures. The chemical properties pH, EC and Available potassium were analysed by Jackson (1973) [10], Organic Carbon were determined by Walkey and Black, 1934, Available Nitrogen by Subbaiah and Asija 1956 [24], Available Phosphorus by the Olsen *et al*. 1954 [15], Available S by Chesnin and Yien 1950 [8], The data obtained under various studies was subjected to statistical analysis for significance using OPSTAT software. All the data related to soil organic carbon and its fractions was subjected to factorial randomized block design. Least square difference was used to compare the treatment effect at P <0.05.

Table 1: Initial physico-chemical properties of the soil in relation to different treatments

Treatment	pH (1:2)	EC 1:2 (dS/m)	ESP (%)	OC (%)	Available PK (kg/ha)	(kg/ha)
F_0G_0	9.8	0.34	45.6	0.33	12	1200
F_0G_1	8.4	0.47	15.4	0.30	14	1252
F_0G_2	8.2	0.65	13.7	0.34	18	1260
F_1G_0	9.2	0.42	38.7	0.34	16	1305
F_1G_1	8.4	0.54	15.9	0.36	19	1320
F_1G_2	8.2	0.76	13.5	0.41	21	1370
F_2G_0	9.5	0.83	40.8	0.42	18	1400
F_2G_1	7.9	0.92	14.6	0.51	22	1428
F_2G_2	8.1	1.02	14.1	0.62	24	1430

Table 2: Ionic composition and quality parameters of irrigation water

Parameter	CO_3^{2-} (me/1)	HCO_3^- (me/1)	Ca^{2+} (me/1)	Mg^{2+} (me/1)	Na^+ (me/1)	Cl^- (me/1)	SO_4^{2-} (me/1)	ECiw (dS/m)	RSCiw (me/1)	SARiw (mmol/1) ½
Values	0.7	13.3	1.0	1.5	15.8	4.0	6.0	2.4	11.5	14.0

Result and Discussion

pH

In the present study, mean value of soil pH was more in sodic water irrigated plots. Continuous use of sodic water for 20 years slightly brought down the soil pH from initial values of 9.8 to 9.4 in control. However, addition of gypsum and FYM further decrease the soil pH. This could be due to movement of Na to lower depth owing to its replacement by Ca. In present study, the highest soil pH was found where gypsum, and FYM was not applied, the increases in soil sodicity from irrigation with sodic water having high residual alkalinity was attributed to the precipitation of calcite in presence of high concentration of carbonates and bicarbonates and build up of Na in the soil. These results are in agreement with those reported by (Singh *et al*. 2004, Pareek and Yadav 2011) [21, 16].
The soil pH in $G_1$and G_2 treatment was significantly lower as compared to the G_0 and it may be due to addition of proton from fatty acids from decomposition and addition of gypsum provides a source of Ca^{2+} which precipitates as $CaCO_3$ and $CaHCO_3$. It may be due to replacement of exchangeable Na^+ during Na^+-Ca^{2+} exchange and subsequent leaching. These results are in agreement with (Singh and Singh 2014) [22] and lowest value of pH was found in G_2 treated plots because of 100% neutralisation of RSC of irrigation water.
The pH decreased with increasing levels of FYM level (from 0 to 20 t/ha) and highest reduction was observed in F_2 treated plots and it may be due to the fact that decrease the precipitation of Ca and Carbonates, increase the removal of Na in drainage water. Similar types of results were obtained by (Sekhon and Bajwa 1993, Sharma and Minhas 1998 and Ansari 2008) [17, 18]. Decrease in pH with addition of organic material may be due to increase in microbes respiration and production of organic acid during decomposition of organic material and as a result of increased pCO_2.

EC

Lower values of EC of soil observed in plot where sodic water alone was applied as compared to amended plots and it may be attributed the fact that amount of Ca and Mg in soil solution decrease owing to its precipitation as carbonates and conversion of soluble sodium to adsorbed state decrease the electrolytic concentration in soil solution, this resultantly decreased the EC of soil (Pareek and Yadav 2011) [16].
The EC was significantly higher in treatments G_2 and G_1 as compared to G_0 treatment and it could be simply because of the sustained addition of Na in the irrigation water, Na and Ca released from the soil exchange complex and salt released due to Gypsum dissolution. Similar result was reported by Sekhon and Bajwa 1993 [17], Sharma *et al*. 2003 [19].
The EC of soil was increased with addition of FYM application, and highest value was found in F_2 treated plots and it may be due to increase of ions in solution, which may have resulted from mineral dissolution caused by increase in partial pressure of carbon dioxide and organic acid. Similar types of results were also reported by Chaudhary *et al*. 2006 [6]. The addition of organic matter may also promote the flocculation by increasing the EC and thus improving the soil structure stability. These results are in agreement with the findings of Tejada *et al*. 2006 [26] and Wong *et al*. 2008.

Available N

The available nitrogen was found lowest in plots where no

FYM and gypsum was applied and it may be due to the fact that in sodic water irrigation, and at high pH, the ammonium volatilisation losses are more, similarly as reported by Yaduvanshi *et al*. 2001 [31]. The increase in available N content with the incorporation of organic source i.e FYM may be attributed to N mineralization from organic manure and result clearly shows that FYM help to increase the available N content of soil due to N mineralization and the favourable soil condition under FYM treatment.

The difference between G_0 and G_2 treatment were found to be significant with respect to available N, of course, available N decrease over their initial status under both treatments (G_0 and G_2). Similar finding were reported by (Singh *et al*. 2009) [20]. The available N was found highest in case of G_2 treatment because of addition of gypsum reduce the soil pH, and at lower pH more microbial activity leads to more nitrogen mineralisation and available N may be increase due to the fixation of N by the microbes. A polynomial relationship was established between OC content of soil and available N (fig.1) having R^2=0.50. This shows that the application of organic manure increased OC content of soil and ultimately increased available N content of soil.

Available P

Available P content of soil was enhanced significantly with gypsum application over no gypsum and it may be due to the fact that the decrease in soil pH resulting in more availability of native and applied P. Similar result was obtained by Singh 2009 [20]. The increase in available P status of soil with addition of FYM, and this may be due to greater mobilization of native soil P. The increase in available P content of soil with addition of FYM may be attributed to decomposition of organic matter accompanied by the release of abundant quantities of CO_2, this CO_2 production plays a dominant role in enhancing the phosphate availability. Organic matter forms a protective cover on sesquioxides and this facilitates reduction in phosphate fixing capacity of soil. Similar result was reported by (Tandon 1987) [27]. Relationship between Organic carbon and available P was polynomial. Regression equation predicts significant relationship between organic carbon and available Phosphorus with R^2=0.73.

Available K

With the increase in FYM level from F_0 to F_2, the soil available K was also increased and highest was found in F_2 plots, and the build up of soil available K due to FYM application may be due to additional supply of K applied through it and the solubilising action of certain organic acid produced during FYM decomposition and its greater capacity to hold K in the available form. The relationship between OC and available K content of soil was polynomial having R^2=0.77.The available K content of soil increased with increasing organic carbon content of soil.

Available Sulphur

The content of available S in soil was increased with increase in level of FYM from F_0 to F_2 treated plots, it may be due to greater mobilization of native soil S and decomposition of organic matter accompanied by the release of abundant quantities of CO_2, this CO_2 production plays a dominant role in reducing the pH and enhancing the sulphur availability. Available S content of soil was significantly enhanced with gypsum application over no gypsum and highest and lowest value for available S was found in the G_2 and G_0 treated plots, it may be due to decrease in soil pH resulting in more availability of native and applied S.A polynomial relationship between Organic carbon and available S. Regression equation predicts that there is significant correlation between organic carbon and available Sulphur with R^2 value of 0.47.

Organic carbon

Twenty years of continuous vegetable cropping without addition of FYM leads to loss of soil organic carbon. The native and additional organic material can become more readily available or easier to decompose as a result of presence of alkali salts, which have potential to dissolve, disperse or cause chemical hydrolysis of organic material (Laura 1976, Chander *et al*. 1994, Sumner *et al*. 1998) [12, 25]. Addition of FYM and gypsum significantly increases the OC content in soil, because under improved soil physical environment, Carbon inputs was more in the forms of more root biomass and above ground small plant residue. Addition of gypsum also increased the aggregation stabilization from the formation of Ca-organic linkage in the form of clay particle-Ca-organic molecule (Baldock *et al.* 2000) [2]. The total organic carbon content in soil increased 62 % and 82% per year with application of FYM @10 and 20 t/ha, respectively over no FYM application. Similarly organic carbon content increased 4.6% and 7.8%, respectively with increasing neutralization of RSC of water from 50 to 100 %. Interaction of FYM and gypsum levels showed significant differences for TOC of soil.

Table 3: Results showing the values of pH, EC, total carbon and available nutrients in soil (0-15 cm) under different treatments combinations.

pH

Treatments	G_0	G_1	G_2	Mean
F_0	9.4	8.2	7.8	8.5
F_1	9.0	7.9	7.7	8.2
F_2	8.8	7.7	7.6	8.0
Mean	9.1	7.9	7.7	
CD at 5% FYM=0.03, Gypsum=0.03, GXFYM=0.05				

EC(dS/m)

Treatments	G_0	G_1	G_2	Mean
F_0	0.48	0.65	0.80	0.64
F_1	0.57	0.70	0.89	0.72
F_2	0.95	1.18	1.41	1.18
Mean	0.67	0.84	1.03	
CD at 5%, FYM=0.019, Gypsum=0.019, FxG =0.033				

Total organic carbon (g/kg)

Treatments	G_0	G_1	G_2	Mean
F_0	4.2	4.5	4.7	4.5
F_1	7.0	7.3	7.5	7.3
F_2	8.0	8.2	8.5	8.2
Mean	6.4	6.7	6.9	
CD at 5% FYM=0.048 Gypsum=0.048 GXFYM=0.083				

Available nitrogen (kg/ha)

Treatments	G_0	G_1	G_2	Mean
F_0	140.00	153.07	168.00	153.69
F_1	147.47	164.50	176.40	162.79
F_2	160.00	175.40	188.00	174.47
Mean	149.16	164.32	177.47	
CD at 5% FYM=3.99 Gypsum=3.99 GXFYM=NA				

Available phosphorus(kg/ha)

Treatments	G_0	G_1	G_2	Mean
F_0	13.2	15.51	19.02	15.91
F_1	17.22	21.04	23.23	20.50
F_2	19.51	24.52	28.61	24.21
Mean	16.64	20.36	23.62	
CD at 5% FYM=1.25 Gypsum=1.25 GXFYM=NA				

Available potassium (kg/ha)

Treatments	G_0	G_1	G_2	Mean
F_0	217.0	200.2	178.4	198.53
F_1	298.5	272.6	261.3	277.47
F_2	327.4	298.2	273.3	299.63
Mean	280.97	257.00	237.67	
CD at 5% FYM=3.72 Gypsum=3.72 FYM x G=6.45				

Available sulphur(kg/ha)

Treatments	G_0	G_1	G_2	Mean
F_0	35	48	57	46.67
F_1	42	56	67	55.00
F_2	50	65	74	63.00
Mean	42.33	56.33	66.00	
CD at 5% FYM=1.532 Gypsum=1.532 FYMXG=NA				

Table 4: Correlation matrix between total carbon and available nutrients in soil

	Total C	pH	EC	AVAL N	AVAL P	AVAL K	AVAL S
Total C	1						
pH	-0.402	1					
EC	0.729^{*}	-0.669^{*}	1				
AVAL N	0.662	-0.892^{**}	0.897^{**}	1			
AVAL P	0.819^{**}	-0.778^{*}	0.921^{**}	0.958^{**}	1		
AVAL K	0.871^{**}	0.061	0.394	0.215	0.444	1	
AVAL S	0.655	-0.912^{**}	0.873^{**}	0.995^{**}	0.952^{**}	0.208	1

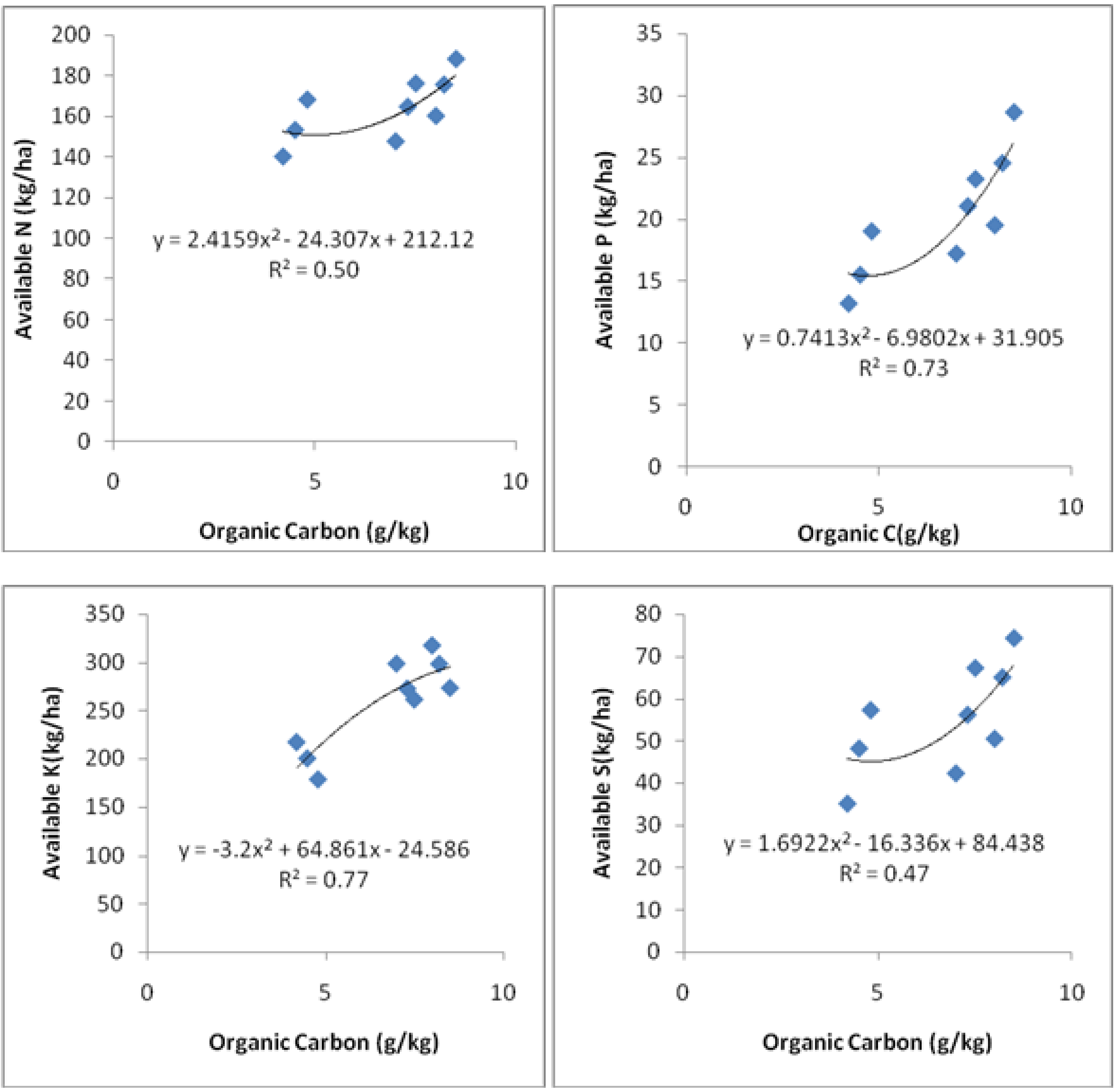

Fig 1: Relationship between organic carbon and available Nutrients content of soil

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