

## The pH, ECe, SAR and Ionic Composition of Saturated Extract as Influenced by Gypsum Application in Sodic Soils

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### Abstract

A field experiment was carried out during 2004-05 at farmer's field to study the effect of gypsum application on ECe, pH, SAR and ionic composition of sodic soils. It was found that the application of gypsum at 11.25 tone per hectare decreased remarkably the pH, SAR and ECe values of sodic soils during all the samplings. On the basis of average values of different sampling times, the reduction was noted as 10.08 to 9.00, 10.27 to 9.52 and 10.18 to 9.77, in pH, 8.08 to 4.79, 7.06 to 5.38 and 6.98 to 4.61 dS/m in ECe and 70.55 to 23.89, 64.20 to 22.29 and 62.01 to 19.86 in SAR values for 0—0.15 m, 0.15—0.30 m and 0.30—0.60 m depth, respectively. A remarkable change in ionic composition of saturated extract was noted with application of amendment. Ca<sup>2+</sup> + Mg<sup>2+</sup> content in the extract enhanced from 2.39 to 6.00, 2.24 to 8.22 and 2.34 to 8.22 me/liter for 0—0.15, 0.15—0.30 and 0.30—0.60 m depth, respectively. An average reduction in Na<sup>+</sup>, K<sup>+</sup> and CO<sub>3</sub><sup>2-</sup> + HCO<sub>3</sub><sup>-</sup> contents of saturated extract were noted as 77.02 to 41.58, 0.54 to 0.29 and 37.69 to nil me/liter for 0—0.15 m depth, 67.96 to 45.20, 0.37 to 0.35 and 32.99 to 20.78 me/liter for 0.15 to 0.30m depth and 67.10 to 40.06, 0.38 to 0.36 and 23.58 to 23.15 me/liter for 0.30 to 0.60 m depth, respectively. The SO<sub>4</sub><sup>2-</sup> and Cl<sup>-</sup> contents in extract increased remarkably for 0—0.15m depth. However, in sub-surface layers, concentration of SO<sub>4</sub><sup>2-</sup> and Cl<sup>-</sup> ions decreased appreciably with gypsum application. Mean reduction in Cl<sup>-</sup> and SO<sub>4</sub><sup>2-</sup> concentration were noted as 16.6 to 15.6 and 20.98 to 17.4me/liter for 0.15 to 0.30m depth and 23.00 to 10.53 and 23.23 to 12.42 me/liter for 0.30—0.60 m depth, respectively.

**Key words :** ECe, SAR, Ionic composition, Gypsum, Sodic Soils.

Salt affected soils are unproductive unless excess salts are reduced or removed. Saline and sodic soils are estimated to cover about 69.5 lakh hectares of land India, out of which 12.9 lakh hectare area of saline and sodic soils are found in Uttar Pradesh (1). Hence vast occurrence of such soils is a major problem and affecting economy of the nation due to poor production or no production. The Agra region of Uttar Pradesh comprising of seven districts i. e., Agra, Aligarh, Firozabad, Etah, Mathura, Mainpuri and Hathras occupies the largest area of two lakh hectare with typical saline/sodic in nature. Alkali soils formed under the influence of sodium carbonate and bicarbonate, limit crop production in the Indo-Gangatic Plains of India and several other parts of the world among to their high pH, ESP and poor soil physical conditions. Among the sodic soil amendments, gypsum (CaSO<sub>4</sub>·2H<sub>2</sub>O) is the most commonly used amendment for amelioration of alkali soils. Gypsum applica-

tion to the alkali soils improved hydraulics conductivity and soil structure and reduced sodicity of the soil (2). Therefore, a study was undertaken at farmer's field in Rajpur Village of Aligarh district Uttar Pradesh to find out the effect of gypsum application on the physico-chemical characteristics of sodic soils.

### Methods

After proper ploughing and leveling the experimental field was divided into two strips of 30×30 m each. One strip of the field was treated with calculated amount of gypsum at 11.25 tone/ha. Both strips of the field were again ploughed to mix the amendment. Both strips were separated into eight plots in each case. The plots were filled with canal water (EC 0.12 and pH 7.15) for twenty days for proper leaching of salts, and minimum 2 cm standing water was maintained during the leaching period. Soil samples from

**Table 1.** Effect of gypsum application on PH, ECe and SAR values of alkali soils.

Treat-ments	Sampling schedule	Depth (m)	pH	ECe	SAR
Control	Jun 2004	0—0.15	10.0	9.20	76.24
	Oct 2004		10.1	7.70	69.54
	Dec 2004		10.2	8.45	72.71
	Feb 2005		10.0	7.97	69.20
	Apr 2005		10.1	6.90	65.26
	Jun 2005		10.1	8.00	70.36
Treated with gypsum	Jun 2004	0—0.15	9.2	6.70	28.15
	Oct 2004		8.8	5.15	24.83
	Dec 2004		9.0	3.65	21.44
	Feb 2005		9.1	3.60	21.06
	Apr 2005		8.7	4.25	22.86
	Jun 2005		9.2	5.37	25.01
Control	Jun 2004	0.15—0.30	10.3	8.20	69.26
	Oct 2004		10.1	6.62	62.28
	Dec 2004		10.3	7.00	63.70
	Feb 2005		10.2	6.50	61.42
	Apr 2005		10.3	6.60	62.19
	Jun 2005		10.4	7.42	66.37
Treated with gypsum	Jun 2004	0.15—0.30	9.6	6.25	23.97
	Oct 2004		9.5	4.90	21.16
	Dec 2004		9.5	4.70	21.52
	Feb 2005		9.4	5.35	22.21
	Apr 2005		9.5	5.32	22.00
	Jun 2005		9.6	5.75	22.86
Control	Jun 2004	0.30—0.60	10.2	7.70	64.88
	Oct 2004		10.2	6.60	60.52
	Dec 2004		10.1	6.95	61.80
	Feb 2005		10.1	6.94	62.36
	Apr 2005		10.2	6.58	60.03
	Jun 2005		10.3	7.12	62.49
Treated with gypsum	Jun 2004	0.30—0.60	9.9	5.20	19.23
	Oct 2004		9.7	5.20	19.25
	Dec 2004		9.7	4.50	17.97
	Feb 2005		9.8	4.48	28.00
	Apr 2005		9.9	3.78	16.73
	Jun 2005		9.6	4.50	17.98

0—0.15, 0.15—0.30 and 0.30—0.60m depth were taken in June 2004, October 2004, December 2004, February 2005, April 2005 and June 2005. The physico-chemical properties of experimental field before initiation of experiment were pH 10.4, 10.4 and 10.2, ECe 10.6, 10.0 and 9.7 dS/m SAR 78.27, 70.60 and 67.00, clay 25, 31 and 21 percent, silt 30.00, 22.00 and 24.00 percent and sand 45.00, 47.00 and 55.00% for 0—0.15, 0.15—0.30 and 0.30—0.60 m depth, respectively. The collected soil samples were processed and analyzed for pH, ECe, SAR, cationic and anionic composition of saturated extract using standard methods of analysis suggested by Richards (3).

## Results and Discussion

### *Effect on Soil pH*

The average pH values of six samplings for 0—0.15, 0.15—0.30 and 0.30—0.60 depth reduced 10.08 to 9.00, 10.27 to 9.52 and 10.18 to 9.77, respectively with the application of gypsum (Table 1). The pH value of 0—0.15 m depth of untreated plots was 10.0, 10.1, 10.2, 10.0, 10.1 and 10.1 during June, October—December 2004, February, April and June 2005, respectively. The pH value of the soil of 0.15—0.30m depth was 10.2, 10.1, 10.3, 10.2, 10.3 and 10.4 in control plots during same sampling time. Gypsum application change these values as 9.2, 8.8, 9.0, 9.1, 8.7, 9.6 for 0.15—0.30 m depth during June, October—December 2004, February—April and June 2005, respectively. Respective pH values for 0.30—0.60 m depth were noted as 10.2, 10.2, 10.1, 10.2 and 10.3 in control plots, while the pH values of gypsum treated plots for the same depth were 9.9, 9.7, 9.7, 9.8, 9.9 and 9.6 respectively. Reduction in pH values of sodic soils by gypsum application might be due to replacement of Na<sup>+</sup> with Ca<sup>2+</sup> from the exchange sites of the soils and leaching to subsurface layers as also earlier reported by Oster and Frenkel (4).

### *Effect on Electrical Conductivity of Saturated Extract*

The data show that gypsum application decreased remarkably the ECe value of sodic soils. Magnitude of ECe reduction was high in surface layer than sub-surface layers for all samplings. Average ECe values of soil samples of 0—0.15 m, 0.15—0.30 m and 0.30—0.60 m depth of control plots were 9.20, 7.70, 8.45, 7.97, 6.90 and 8.00, 8.20, 6.62, 7.00, 6.50, 6.60 and 7.42 and 7.70, 6.60, 6.95, 6.94, 6.58 and 7.12 dS/m during June, October, December 2004, February—April and June 2005, respectively. While ECe values of gypsum treated plots were found as 6.70, 5.15, 3.65, 3.60, 4.25 and 5.37 dS/m for 0.15—0.30 m depth and 5.20, 5.20, 4.50, 4.48, 3.78 and 4.50 dS/m for 0.30 to 0.60 m depth respectively during the same sampling timings. The gypsum application reduced ECe values by 40.72, 23.80 and 33.95% for 0—0.15, 0.15—0.30 and 0.30—0.60 m depth, respectively. Gypsum application improved the physical condition of soil, which contribute to decrease the salt status of soil through sufficient leaching (5).

**Table 2.** Ionic composition (me/liter ) of saturation extract of soils with respect to gypsum application.

Treatments	Sampling schedule	Depth (m)	Ca <sup>2+</sup> + Mg <sup>2+</sup>	K <sup>+</sup>	Na <sup>+</sup>	CO <sub>3</sub> <sup>-</sup> + HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>
Control	Jun 2004	0—0.15	2.73	0.58	89.05	43.22	23.00	25.78
	Oct 2004		2.28	0.52	74.20	35.82	19.50	21.68
	Dec 2004		2.51	0.55	81.44	39.52	20.99	23.99
	Feb 2005		2.35	0.60	74.95	37.67	20.60	21.37
	Apr 2005		2.08	0.42	66.50	32.17	17.00	19.83
	Jun 2005		2.40	0.55	77.05	37.71	18.96	23.33
Treated with gypsum	Jun 2004	0—0.15	8.52	0.41	58.07	Nil	31.60	35.4
	Oct 2004		6.49	0.29	44.72		24.00	27.5
	Dec 2004		4.42	0.22	31.86		15.90	20.6
	Feb 2005		4.43	0.23	31.34		15.90	20.1
	Apr 2005		5.25	0.22	37.03		20.00	22.5
	Jun 2005		6.90	0.35	46.45		26.10	27.6
Control	Jun 2004	0.15—0.30	2.60	0.44	78.96	38.10	19.00	24.90
	Oct 2004		2.10	0.32	63.78	30.22	15.10	20.88
	Dec 2004		2.24	0.36	67.40	32.20	17.00	20.80
	Feb 2005		2.08	0.33	62.59	30.22	15.50	19.28
	Apr 2005		2.09	0.35	63.56	31.20	16.00	18.80
	Jun 2005		2.32	0.40	71.48	36.00	17.00	21.20
Treated with gypsum	Jun 2004	0.15—0.30	9.60	0.40	52.50	24.00	18.90	19.6
	Oct 2004		7.55	0.35	41.10	19.30	15.00	14.7
	Dec 2004		6.84	0.28	39.80	17.90	13.20	15.9
	Feb 2005		8.20	0.35	44.95	20.00	15.00	18.5
	Apr 2005		8.22	0.35	44.60	21.00	15.50	16.7
	Jun 2005		8.91	0.35	48.24	22.50	16.00	19.0
Control	Jun 2004	0.30—0.60	2.60	0.44	73.96	26.00	25.10	25.9
	Oct 2004		2.20	0.37	63.43	22.40	21.90	21.7
	Dec 2004		2.34	0.35	66.81	23.50	23.00	23.00
	Feb 2005		2.29	0.38	66.73	23.60	22.90	22.9
	Apr 2005		2.22	0.36	63.22	22.00	22.00	21.8
	Jun 2005		2.40	0.37	68.43	24.00	23.10	24.1
Treated with gypsum	Jun 2004	0.30—0.60	9.56	0.40	42.04	26.20	12.20	13.6
	Oct 2004		9.54	0.42	42.04	26.30	13.00	12.7
	Dec 2004		8.22	0.36	36.42	22.50	10.00	12.5
	Feb 2005		8.20	0.33	52.67	22.42	9.15	13.23
	Apr 2005		6.75	0.31	30.74	19.00	8.40	10.40
	Jun 2005		8.22	0.34	36.44	22.50	10.00	12.10

#### *Effect on Sodium Adsorption Ratio*

Application of gypsum decreased remarkably the sodium adsorption ratio (SAR) of soil. SAR values of control plots of 0—0.15m, 0.15—0.30 and 0.30—0.60 m depth were 76.24, 69.54, 72.71, 69.20, 65.26 and 70.36, 69.26, 62.25, 63.70, 61.42, 62.19 and 66.37 and 64.88, 60.50, 61.80, 62.36, 60.03 and 62.49 during June, October, December 2004, February April and June 2005, respectively. The corresponding SAR values of gypsum treated plots were 28.15, 24.83, 21.44, 21.06, 22.86 and 25.01, 23.97, 21.16, 21.52, 22.21, 22.00 and 22.86 and 19.23, 19.25, 17.97, 28.00, 16.73 and 17.98 for the same sampling timings. Percent reduction in SAR

values was noted as 66.14, 65.28 and 67.97 for 0—0.15m, 0.15—0.30 and 0.30—0.60m depth, respectively. Gypsum application reduced the sodium concentration and increased Ca<sup>2+</sup> and Mg<sup>2+</sup> concentration on exchange complex of the soils which ultimately reduced the SAR values of soil as also earlier noted by Singh and Bajwa (6).

#### *Effect on Ionic Composition of Saturation Extract*

*Effect on Soluble Cations.* Gypsum application appreciably enhanced Ca<sup>2+</sup> + Mg<sup>2+</sup> concentration in saturated extract of the soil at all the timings of soil sampling (Table 2). The sodium content in saturated

extract reduced remarkably with application of gypsum. However  $K^+$  concentration did not show distinct variation with gypsum application. The extent of  $Na^+$  reduction was 77.02 to 41.58, 67.96 to 45.20 and 67.10 to 40.06 me/liter for 0—0.15, 0.15—0.30 and 0.30—0.60 m depth, respectively. The  $Ca^{2+} + Mg^{2+}$  concentration of saturated extract enhanced with gypsum application to the extent of 2.39 to 6.00, 2.24 to 8.22 and 2.34 to 8.22 me/liter for 0—0.15, 0.15 to 0.30 and 0.30 to 0.60 m depth, respectively. While cationic type remained  $Na^+ - (Ca^{2+} + Mg^{2+}) - K^+$  type in saturated extract of soil. These results are in agreement with those of (5).

*Effect on Soluble Anions.* The gypsum application reduced remarkably the carbonate and bicarbonate concentration of saturated extract of the soil. It was found that gypsum application reduced the  $CO_3^{2-} + HCO_3^-$  concentration from 37.69 to nil, 32.99 to 20.78 and 23.58 to 23.15 me/liter for 0—0.15, 0.15—0.30 and 0.30—0.60 m depth, respectively. The extent of reduction was 100, 37.01 and 1.82% for corresponding sampling depth, respectively. The  $Cl^-$  concentration of saturated extract change from 16.6 to 15.6 and 23.00 to 10.53 me/l for 0.15—0.30 m and 0.30—0.60 m depth, respectively. However, the change in  $SO_4^{2-}$  concentration for same sampling depth was 20.98 to 17.4 and 23.23 to 1.42 me/liter, respectively. Average  $Cl^-$  and  $SO_4^{2-}$  content in saturated extract increased remarkably in 0—0.15 m soil depth with the application of gypsum. This observation is in accordance with those of Sharma and Dev (7).

### Conclusion

The results of the study lead to the conclusion

that gypsum application to alkali soils reduced remarkably the pH and SAR values. ECe of the soils was also decreased due to gypsum application. Calcium and magnesium content in the saturated extract enhanced remarkably with the use of gypsum. A notable reduction in sodium, carbonate and bicarbonate contents of the extract were recorded in gypsum treated plots. In other hands,  $Cl^-$  and  $SO_4^{2-}$  content in saturated extract of upper layer soils increased remarkably with application of amendment. While  $K^+$  ions were almost equal in both, gypsum treated and control plots. Concentration of toxic cations and anions reduced appreciably with the use of gypsum.

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