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IMPACT OF ALKALI WATER AND GYPSUM ON GROWTH AND YIELD OF RICE AND SOIL PROPERTIES

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ABSTRACT

A field experiment was conducted at Crop Research Farm, Nawabganj Kanpur (U.P.) during kharif seasons of 2009 to 2014 to study the effect of alkaline water and gypsum on yield of rice and soil properties. Application of gypsum @ 25, 50 and 100% GR alone and in combination with alkali water passing through 15 cm gypsum bed was significantly superior over control with respect to growth and yield of rice. The maximum grain and straw yield (47.41 and 54.78 q ha^{-1}) was recorded with the application of gypsum (50% GR) and alkali water passing through 15 cm gypsum bed treatment. The changes in pH, EC, SAR and RSC of alkali irrigation water were from 8.2 to 7.8, 1.19 to 1.47, 10.2 to 4.7 m $mol^{1/2}$ $L^{-1/2}$, and 8.75 to 4.02 me L^{-1}, respectively when the alkali water was passed through 15 cm gypsum bed. The maximum reduction in pH, EC and ESP was recorded 8.01, 1.15 dSm^{-1} and 20.0, respectively with the application of gypsum (50% GR) + 15 cm gypsum bed treatment. Use of alkali water irrigation (control) considerably raised the pH, EC and ESP of soil to 10.0, 2.83 dSm^{-1} and 66.15, respectively from the corresponding initial values. Highest B:C ratio (1.91) with net return of ⁚ 67959 was accrued due to the soil application of gypsum (50% GR) + gypsum bed (15 cm) treatment of alkali water followed by soil application of gypsum (100% GR) and lowest B:C ratio (1:1.0) and net return of ⁚ 32012 in control. There was an increase in uptake of N, P, K, Zn, Ca and Mg due to different treatments over control. Exchangeable Na appeared to increase the adverse effect of sodium on plant growth in sodic soil. There was a decrease in uptake of Na due to decreasing level of ESP.

Keywords: Alkali irrigation water, gypsum bed, yield, rice, nutrients uptake, soil properties.

INTRODUCTION

In arid and semi- arid regions, use of saline and sodic water for irrigation in the absence of appropriate soil-water-crop management practices, often leads to the buildup of salinity and sodicity in the soil profile which adversely affect the crop productivity. Each year approximately 10 million hectares (Mha) of the worlds irrigated land is abandoned mainly due to secondary salinization and sodication as a consequence of adverse effect of irrigation. In some parts of Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Andhra Pradesh and Karnataka, the underground water available for irrigation has high sodicity (EC- variable, SAR>10 and RSC> 4 me L^{-1}). The sodic water containing residual sodium carbonate (RSC) more than 2.5 me L^{-1} has been considered unsatisfactory for the irrigation (Wilcox *et al.* 1954). However, Gupta (1983) reported that the irrigation water containing RSC as high as 10 me L^{-1} (EC- 2 dSm^{-1}, SAR< 10) can be applied continually without affecting the yield on loam soils where rainfall is 500-550 mm during the monsoon season. Application of gypsum @ 50% GR and alkali water passing through 15 cm gypsum bed treatment minimize the harmful effects of sodic water irrigation on the crop yield and soil properties (Yadav and Chhipa 2005). In the back ground of this information, the present study was undertaken to study the impact of alkali water and gypsum application on yield, growth parameter on rice and soil properties.

MATRIALS AND MTHODS

A field experiment was conducted at Crop Research Farm, Nawabganj of C.S. Azad University of Agriculture and Technology, Kanpur during kharif seasons of 2009 to 2014. The soil characteristics of experimental field were: pH 9.5, EC 2.41 dSm^{-1}, organic carbon 1.2 g kg^{-1} and exchangeable sodium percentage (ESP) 57.10. Tube-well water used for irrigation was alkali in nature with pHiw 8.2, ECiw 1.19 dSm^{-1}, SAR 10.2 m $mol^{1/2}$ $L^{-1/2}$ and RSC 8.83 me L^{-1}. The experiment was laid out in a randomized block design with seven treatments, each being replicated four times. The treatments consisted: T_1 control (alkali water), T_2 gypsum bed (15 cm) treatment (GBT) of alkali water, T_3 soil application (SA) of gypsum (25% GR), T_4 soil application of gypsum (25% GR) + gypsum bed (15 cm) treatment of alkali water, T_5 soil application of gypsum (50% GR), T_6 soil application of gypsum (50% GR) + gypsum bed (15 cm) treatment of alkali water and T_7 soil application of gypsum (100% GR). A specially designed tank (1m x 1m x 1m) was constructed and the height of gypsum bad in tank was adjusted by placing 6mm diameter steel bar at 15 cm height. The quantity of gypsum applied was based on

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the calculation of the GR. The calculated value of 25 and 50% GR was 1.25 and 2.50 t ha^{-1}, respectively.

The depth of gypsum bed was kept 15cm based on the study of Pal and Poonia (1979) conducted at Hissar. The variety CSR-27 of rice was tested with the recommended dose of fertilizers and agronomical practices were adopted as per requirement of crop. Soil application of gypsum was done prior to the last harrowing of the experimental field. The soil samples and quality of tube - well water were analyzed for different parameters as suggested by Richards (1954). At maturity, the growth, yield attributes and yields of grain and straw were recorded. Grain and straw samples of rice were digested in di acid (HNO_3 and $HClO_4$) and digests were subjected to analysis of P by vanadomolybdophosphoric acid yellow colour method. Na nd K by flame photometer, Ca and Mg by versenate titration using ammonium purpurate and eriochrome black T (EBT) as indicator for Ca and Ca + Mg, respectively and zinc by actomic absorption soectrophotometer. Nitrogen was determined by Kjeldhal method. The percent nutrient content in grain and straw was multiplied by the respective yield to calculate the uptake of nutrients. The economics of treatments was calculated on the basis of prevaiting market price of inputs and produce.

RSULTS AND DISCUSSION

Quality of Irrigation water:

Results showed considerable improvement in irrigation water quality when the water was passed through 15 cm gypsum bed (Table-1). Ionic composition of untreated and gypsum bed treated alkali irrigation water revealed absence of carbonate in alkali irrigation water but rich in bicarbonate (10.65 me L^{-1}) with relatively very less amount of chloride (0.75 me L^{-1}) and sulphate (0.47 me L^{-1}) anions. Sodium and potassium were the dominant cations (9.65 me L^{-1}) in untreated alkali irrigation water that contained relatively less amount of Ca and Mg (1.82 me L^{-1}). Gypsum bed treatment of alkali irrigation water reduced bicarbonate and sodium ions content by 0.52 and 1.38 me L^{-1}, respectively with considerable increase in sulphate (3.10 me L^{-1}) and calcium (4.30 me L^{-1}) ions. The changes in pH, EC, SAR and RSC of alkali irrigation water were from 8.2 to 7.8, 1.19 to 1.47 dSm^{-1}, 10.2 to 04.7 m $mol^{1/2}$ $L^{-1/2}$, and 8.75 to 4.02 me L^{-1} respectively when the alkali water was passed through 15 cm gypsum bed. This needs further investigation in respect of various depths of gypsum bed and their subsequent effect on neutralization of the RSC irrigation groundwater. The supply of Ca through gypsum increases the concentration of Ca^{2+} and thus decreases RSC and SAR of alkali water.

Table 1: Change in pH, EC, SAR, RSC and ionic composition of alkali waters as a result of 15 cm gypsum bed treatment

Treatment	**pH**	**EC (dSm^{-1})**	**Anion (me L^{-1})**				**Cation (me L^{-1})**		**SAR**	**RSC**
			CO_3	**HCO_3**	**Cl**	**SO_4**	**Ca + Mg**	**Na + K**		
Untreated	8.25	1.19	Nil	1.65	0.75	0.47	1.82	9.65	10.2	8.83
Treated	7.84	1.47	Nil	10.13	0.92	3.57	6.12	8.27	0.47	4.02
Change										
(+)	-	0.28	-	-	0.17	3.10	4.30	-	-	-
(-)	0.41	-	-	0.52	-	-	-	1.38	0.55	4.81

Yield attributes and yield

The different treatments significantly influenced the grain and straw yield of rice (Table 2). Soil application of gypsum @ 25, 50 and 100% GR alone and in combination with alkali water passing through 15 cm gypsum bed was found significantly superior over untreated plot with respect to growth, yield attributes and yield (control). The maximum grain and straw yield (47.41 and 54.78 q ha^{-1}) was recorded with the application of gypsum (50% GR) and alkali water passing through 15 cm gypsum bed treatment followed by soil application of gypsum (100% GR). The other treatments were statistically at par with each other in case of rice yield. The gypsum application either through dissolution or soil enhanced the yield of grain (65.2%) and straw (66.9%) over control. Decrease in residual alkalinity, neutralization of groundwater residual sodium carbonate and increase in water soluble Ca^{2+} by passing alkali groundwater through gypsum bed might have resulted in enhancement in yield of rice (Pal and Poonia 1979). The maximum productive tillers (378), plant height (95.55 cm), panicle length (25.9 cm), grains/panicle (120) and test weight (33.83 g) with the application of gypsum (50% GR) + gypsum bed of alkali water treatment followed by soil application of gypsum (100% GR). The soil application of gypsum along with gypsum bed treatment of alkali water significantly improved the yield attributes compared with soil application of gypsum alone.It is further observed that application of gypsum through gypsum bed gave higher B: C ratio as compared to its soil application. However, highest B:C ratio (1.91) with net return of `. 67959 ha^{-1}

Table 2: Effect of treatments on yield and yield attributing characters of rice crop

Treatment	Grain (q ha^{-1})	Straw (q ha^{-1})	Tillers/ m^2	Plant height (cm)	Panicle length (cm)	Grain/ Panicle	Test weight (g)	Net Returns (` ha^{-1})	B: C Ratio
T_1	21.75	25.06	285	78.27	16.4	95	23.10	32012	1:1.0
T_2	30.75	35.14	353	84.25	21.4	105	27.82	41104	1:1.4
T_3	28.47	32.82	350	80.66	19.0	100	26.51	40801	1:1.3
T_4	33.39	36.35	354	89.72	24.0	115	29.00	47709	1:1.5
T_5	33.25	37.88	345	86.72	23.3	111	28.10	47679	1:1.4
T_6	47.41	54.78	378	95.55	25.9	120	33.83	67959	1:1.9
T_7	44.27	51.26	360	91.23	24.7	117	31.55	63553	1:1.7
CD (P=0.05)	1.72	2.14	8.32	3.11	1.56	4.84	1.55	--	--

was accrued due to the soil application of gypsum (50% GR) + gypsum bed (15 cm) treatment of alkali water followed by soil application of gypsum (100% GR) and lowest B:C ratio (1:1.0) with net return of ` 32012 were observed in control plot.

Uptake of Nutrients:

Nitrogen uptake varied from 19.2 to 41.7 kg ha^{-1} in grain and 8.2 to15.5 kg ha^{-1} in straw, P from 4.6 to 10.0 kg ha^{-1} in grain and 5.5 to 13.3 kg ha^{-1} in straw, K from 4.9 to 11.1 kg ha^{-1} in grain and 44.5 to 71.2 kg ha^{-1} in straw, Zn uptake varied from 20.1 to 42.4 g ha^{-1} in grain and 103.2 to 143.5 g ha^{-1} in straw, Ca from 1.9 to 7.9 kg ha^{-1} in grain and 1.5 to 5.6 kg ha^{-1} in straw, Mg varied from 3.0 to 7.9 kg ha^{-1} in grain and 2.3 to 6.6 kg ha^{-1} in straw and Na from 1.5 to 2.4 kg ha^{-1} in grain and 3.3 to 4.9 kg ha^{-1} in straw (Table 3). There was an increase in uptake of N, P, K, Zn, Ca and Mg due to different treatments over control. There was a decrease in uptake of Na due to decreasing level of ESP. The maximum and minimum uptakes were recorded in gypsum (50% GR) + GBT of sodic water and control, respectively. For obtaining 47.41 q ha^{-1} grain and 54.78 q ha^{-1} straw yields, the net nutrient removal of 57.2 kg ha^{-1} N, 23.3 kg ha^{-1} P, 82.2 kg ha^{-1} K,185.93 g ha^{-1} Zn , 13.6 kg ha^{-1} Ca,14.5 kg ha^{-1} Mg and 5.0 kg ha^{-1} of sodium was observed in this study. (Singh *et al.* 2010, Kumar *et al.* 2012).

Table 3: Uptake of N, P, K (kg ha^{-1}) Zn (g ha^{-1}) and Ca, Mg, Na (kg ha^{-1}) in rice as affected by different treatments

Treatment	N		P		K		Zn		Ca		Mg		Na	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	19.2	8.2	4.6	5.5	4.9	44.4	20.1	103.2	1.9	1.5	3.0	2.3	2.4	4.9
T_1	27.1	11.7	6.4	8.8	6.9	53.6	26.5	116.4	3.1	2.8	4.6	4.2	1.7	4.3
T_1	24.5	10.2	5.5	7.4	5.2	49.4	23.4	111.1	3.4	3.6	4.5	4.3	1.8	5.2
T_1	32.7	12.6	7.6	9.7	8.2	64.2	28.2	127.4	4.6	4.3	5.3	5.0	1.7	3.9
T_1	31.5	120.0	7.2	9.4	7.9	61.0	26.0	126.5	4.7	4.1	4.9	4.9	1.7	3.6
T_1	41.7	15.5	10.0	13.3	11.1	71.2	42.4	143.5	7.1	6.5	7.6	6.5	1.5	3.5
T_1	38.6	14.1	9.7	12.4	9.7	67.7	39.4	138.2	7.9	5.6	7.5	6.6	1.9	3.7
CD = (0.05)	2.21	1.13	0.52	1.01	0.57	7.48	2.11	9.53	0.32	0.27	0.35	0.25	0.21	0.23

Soil properties

Changes in physico-chemical properties of soil due to implementation of treatments for five years (Table 4) revealed that alkali water irrigation (control) considerably raised the value of pH, EC and ESP of soil to 10.0, 2.83 dSm^{-1} and 66.15 respectively from the corresponding initial values of 9.5,2.42 dSm^{-1} and 57.10. A significant reduction in pH of soil over control was observed due to various combination of soil application of gypsum and passing alkali water through gypsum bed. The maximum reduction in pH was noticed with application of gypsum (50% GR) + 15 cm gypsum bed treatment (8.0), followed by soil application of gypsum (100% GR) alone (8.2). Soil application of gypsum (50% GR) and 15 cm gypsum bed treatment of alkali water and remaining combinations were at par with each other (Sonune *et al.*, 2011).

Table 4: Change in physico-chemical properties of soil as affected by the treatments

Treatments	pH	EC (dSm^{-1})	ESP
T_1	10.0	2.83	66.15

T_2	8.4	2.12	35.55
T_3	8.6	2.17	50.27
T_4	8.6	2.07	35.12
T_5	8.2	1.52	25.22
T_6	8.0	1.87	20.00
T_7	8.2	1.15	27.24

There was a slightly reduction in the EC of soil due to addition of gypsum either through soil application or passing alkali water through gypsum bed. The maximum reduction in EC (from 2.42 to 1.15 dSm^{-1}) was with the soil application of 100% GR alone followed by soil application of gypsum (50% GR) (from 2.42 to 1.52 dSm^{-1})) and soil application of gypsum (50% GR) + gypsum bed (15 cm) treatment of alkali water (from 2.42 to 1.87 dSm^{-1}). Application of gypsum through soil and gypsum bed significantly reduced the ESP of soil over control. Both the levels of gypsum either through soil application or through irrigation water and both were statistically at par. Gypsum is more effective in reclaiming sodic soil by lowering ESP and increasing exchangeable Ca^{2+}, this is mainly because gypsum not only supplies Ca^{2+} but also helps in solubilization of native $CaCO_3$ present in the soil (Swarup 1988 and Shishodia *et al.* 2012).

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