Indian Journal of Agronomy 62 (3): 382–385 (September 2017)

Research Communication

Utilization of high residual sodium carbonate water neutralized with chemical amendments for fodder sorghum (*Sorghum bicolor*) production

POOJA GUPTA SONI[1], RAJENDER KUMAR YADAV[2], GAJENDER YADAV[3] AND TARAMANI YADAV[4]

ICAR-Central Soil Salinity Research Institute, Karnal, Haryana 132 001

Received : April 2016; Revised accepted : June 2017

ABSTRACT

The effect of high residual sodium carbonate (RSC) irrigation water and its neutralization with gypsum/H_2SO_4 on sorghum [*Sorghum bicolor* (L.) Moench] was evaluated in a micro-plot experiment during rainy (*kharif*) season (May to September 2013) at ICAR-Central Soil Salinity Research Institute, Karnal, Haryana. The experiment was conducted in randomised block design, consisted of 5 treatments of different RSC levels [RSC nil (control), RSC 5meq/L, RSC 10meq/L, RSC 10meq/L (neutralized 5meq/L with gypsum), RSC 10meq/L (neutralized 5meq/L with H_2SO_4)] with 4 replications. Increase in concentration of RSC in water from RSC 5 to 10 resulted in reduction in growth parameters like plant height, leaf to stem green biomass, leaf area index, but extent of reduction was lesser, while using RSC water reclaimed with gypsum and sulphuric acid. Neutralization of RSC in irrigation water with gypsum proved a safer and economical option to use high RSC groundwater for irrigation of sorghum for profitable fodder production as compared to sulphuric acid.

***Key words* :** Fodder sorghum, Gypsum, H_2SO_4, Residual sodium carbonate

The scarcity of good quality irrigation water is one of the major issues around the globe in general and in arid and semi-arid regions in particular. In India, about 50% of the groundwater is either marginal or poor in quality. Of this, 37% has high sodicity, 20% has high salinity and remaining 43% has high salinity as well as sodicity. Ground water surveys have shown that about 41–84% of the well water in different states of the Indo-Gangetic plains is brackish (Minhas and Bajwa, 2001). Ground water with higher RSC are common in central and south western parts of Punjab covering about 25% of the total area of the state (Bajwa *et al.*, 1975).

Gypsum is the most extensively used amendment for the reclamation of sodic soils because of its low cost, general availability, and rich supply of Ca^{2+} followed by leaching, can ameliorate saline-sodic soils (Ghafoor *et al.*, 2008; Murtaza *et al.*, 2009). However, in addition to gypsum, sulphuric acid is also considered as the most efficient in neutralizing the sodicity and alkalinity of irrigation water (Kumar and Chhabra, 1996; Lotovitskii and Bilai, 2001). Use of such water would not only permit the sustainable and productive use of sodic water for horizontal expansion of irrigated agriculture, but would also reduce associated environment problems (Oster and Grattan, 2002). Reports suggest that the crops grown for grain production are more sensitive to irrigation water quality in comparison to fodder crops. Among fodder crops, the adverse effect of salty water is more on leguminous crops as compared to grassy fodder crops (Yadav *et al.*, 2007). At present, the country faces a net deficit of 36% green fodder, 11% dry crop residues and 44% concentrates (Vision 2050, IGFRI). There is a large gap between requirement and availability of quality fodder and feed at the national level. It is matter of prime concern to bridge this gap. The sorghum is more salt tolerant crop with good fodder yields as compared to maize and Sudan grass. This experiment, therefore, investigated the consequences of application of high RSC irrigation water and after its neutralization with gypsum/H_2SO_4 on fodder sorghum production.

The study was conducted during rainy (*kharif*) (May to September) 2013 in micro-plots at ICAR-Central Soil Salinity Research Institute, Karnal, Haryana, India (29°43'N, 76°58'E, 245 m above mean sea level, on soil slightly alkaline in reaction (*p*H 8.3–9.2), low-electrical conductivity (ECe 0.47–1.29), low in available nitrogen (176–230 kg/ha) high in available phosphorus (30–47 kg/ha) and me-

Based on a part of M.Sc. Thesis of the first author, submitted to ICAR-NDRI, Karnal, Haryana 2013 (Unpublished)

[3]**Corresponding author's Email:** gajender.icar@gmail.com
[1,4]Research Scholar, ICAR-NDRI, Karnal; [2]Principal Scientist, [3]Scientist, ICAR-CSSRI, Karnal, Haryana

dium in potassium (234.9–295.3 kg/ha). Climate of experimental site is sub-tropical monsoon type and rainfall is received mainly during July to September. The lowest weekly mean temperature (19.3°C) recorded in 30 April–6 May and highest temperature 44.2°C was recorded in 21–27 May. The total rainfall during the growing period was 649.3 mm and remaining water requirement of the crop was met by irrigation.

Multi-cut forage sorghum hybrid 'Raseela' ('MFSH 4') was used as test crop in the study. The experiment conducted in RBD with 4 replications, consisted of 5 treatments of different RSC levels [RSC–nil (control), RSC–5meq/L, RSC–10meq/L, RSC–10meq/L (neutralized 5meq/L with gypsum), RSC – 10 meq/L (neutralized 5 meq/L with H_2SO_4)]. There were 20 micro-plots of 2 × 2 m^2 size in total. The seeds were sown on May 7, by *pora* method with 8 rows in each micro-plot and the row distance was 25 cm. First cut was taken at 65 DAS and second cut was taken at 50 days after first cut. Leaf area was recorded by portable leaf area meter CI-202. The value obtained by the meter (cm^2) entered in the formula and LAI calculated as below:

$$\text{LAI} = \frac{\text{Average leaf area} \times \text{No. of leaves} \times \text{No. of plants}}{\text{Plot area}}$$

The *p*H, ECe, organic carbon, available nitrogen, phosphorus and potassium were determined using standard method for each parameter following the methods of Page *et al*. (1982). Fodder quality; crude protein, ash content etc. were determined in the fodder samples using standard procedures (AOAC, 2005). Each variable was analysed statistically using (GenStat® 13th Edition, VSN International Ltd., Lawes Agricultural Trust, Rothamsted, UK) statistical software.

The RSC in irrigation water had negative effect on plant height of sorghum and the magnitude of reduction increased with the increase in RSC from control to 5 and to 10meq/L (Table 1). The total reduction in plant height at RSC-10 was 52.4% (1st cut) as compared to control, but the reduction in plant height was lesser when RSC-10 neutralized with gypsum and/or H_2SO_4. This is due to osmotic and specific ion effects together with imbalance plant nutrient supply, especially Ca^{2+} and K^+ due to continuous use of sodic water affect on plant growth (Qadir and Schubert, 2002).

Results depicted in Table 1 showed that the reduction in leaf area index at RSC-10 was 48.1%, but the reduction was mitigated to 20.1% in case of RSC-10 + gypsum as compared to control. The major impact of increasing RSC on decrease in plant growth was due to the specific ion effect, i.e. sodium induced calcium deficiency or sodium toxicity or both. According to Kumar *et al.* (2006) the use of alkali waters having high RSC adversely affected the oat growth. These adverse effects can be moderated through the use of gypsum as amendment.

The data depicted in table 1 showed that the lowest leaf to stem green biomass was recorded for RSC-10 in irrigation water treatment at first cut (0.25) as well as for second cut (0.24). The leaf to stem dry biomass decreased with increase in RSC of irrigation water *i.e* from RSC-5 to10 meq/L. The reduction in leaf to stem dry biomass at RSC-5, RSC-10, RSC-10+gypsum and RSC 10 + H_2SO_4 over the control was 14.2, 23.9, 14.7 and 21.0% at first cut and 14.5, 18.8, 13.2 and 20.0% at the second cut, respectively. There is significant difference in leaf to stem dry biomass between RSC-10 and control and rest treatments were at par with control at both first and second cut. Again, the moderating effects of amendments were observed in case of leaf to stem green and dry biomass and more so in case of use of gypsum. In general, growth of crops decrease with increase in RSC of irrigation water and more so the leafiness thereby leading to decrease in leaf to stem ratio (Singh *et al*., 1994).

The reduction in green fodder yield was less with amendment water (with gypsum and H_2SO_4), which was 40.2% and 44.3% respectively (Table 2). Realization of higher yield with application of gypsum might be due to improved soil physical conditions leading to better aeration, root activity and nutrient absorption (Venkata Rao *et al*., 2014).

Table 1. Effect of different RSC levels in irrigation water with and without amendments on growth parameters of fodder sorghum

Treatment	Plant height	Leaf area index	Leaf to stem green biomass		Leaf to stem dry biomass	
	First cut	First cut	First cut	Second cut	First cut	Second cut
Control	219.4	3.47	0.320	0.288	0.307	0.284
RSC-5	140.7	2.56	0.271	0.257	0.263	0.243
RSC-10	104.5	1.80	0.254	0.241	0.234	0.231
RSC-10 + gypsum	137.4	2.77	0.280	0.263	0.262	0.247
RSC-10 + H_2SO_4	127.8	2.60	0.265	0.252	0.242	0.228
SEm±	19.47	0.18	0.016	0.012	0.016	0.017
CD (P=0.05)	42.4	0.39	0.035	0.026	0.035	0.037

Table 2. Effect of different RSC levels of irrigation water with or without amendments on fodder sorghum yield, quality and economics

Treatment	Total green fodder yield (t/ha)	Total dry fodder yield (t/ha)	Crude protein content (%)	Ash content (%)	Cost of cultivation (× 10³ ₹/ha)	Net returns (× 10³ ₹/ha)	Benefit: cost ratio
Control	45.31	7.91	8.94	9.04	24.0	21.3	0.89
RSC-5	25.96 (42.7%)	5.05 (36.21%)	7.47 (16.4%)	9.65 (6.86%)	24.0	2.0	0.08
RSC-10	16.08 (64.5%)	4.14 (47.64%)	4.22 (52.8%)	10.34 (14.44%)	24.0	-7.9	-0.32
RSC-10 + gypsum	27.11 (40.2%)	5.61 (29.12%)	7.41 (17.1%)	9.71 (7.47%)	24.2	2.9	0.12
RSC-10 + H_2SO_4	25.25 (44.3%)	4.99 (36.89%)	7.28 (18.5%)	9.44 (4.48%)	48.3	-23.1	-0.48
SEm±	1.22	0.29	0.20	0.16			
CD (P=0.05)	2.67	0.64	0.44	0.35			

Figures in parenthesis indicate reduction in various parameters as compare to control (except ash content)

The reduction in dry fodder yield in RSC-10 was 47.6%. There was less reduction in dry fodder yield on amendment of RSC water with gypsum and H_2SO_4, which was 29.1% and 36.9% respectively. Yadav *et al.* (2004) reported a linear decline in yield of 5 forage crops: oat (*Avena sativa*), rye grass (*Lolium rigidum*), Indian clover (*Melilotus indica*), Egyptian clover (*Trifolium alexandrinum*) and Persian clover (*Trifolium resupinatum*) with increases in the quantity of salt applied in irrigation water. The reduction in crude protein content in RSC-10 was 52.8%. Lesser reduction in crude protein content was recorded with amended water (gypsum and H_2SO_4) which was 17.1% and 18.5% respectively. The increase in total ash content with RSC-10 irrigation water was 14.4% as compared to control.

The cost of cultivation for treatments of RSC-5 and RSC-10 were same as that of control because of consideration of natural availability of sodic water, but charges of gypsum and H_2SO_4, that were use for neutralization of RSC water, were considered (Table 2). The highest cost of cultivation incurred in case of RSC-10 + H_2SO_4, because the H_2SO_4 is very expensive (₹348/L). Gypsum was economical, though H_2SO_4 can reclaim sodic soils relatively at a faster rate, but at a 5–10 times higher cost as also observed earlier by Ghafoor *et al*., (2001). The highest net returns was obtained (₹21,346/ha) under the control, followed by RSC-10 + gypsum (₹2,889/ha). The highest benefit: cost ratio (0.89) was obtained for the fodder grown in control, followed by RSC-10 + gypsum and the lowest benefit: cost ratio (-0.48) was found for the plots irrigated with RSC-10 + H_2SO_4 water.

Based on the study, a it was concluded that irrigation using increasing levels of RSC in water from 5 to 10 resulted significant reduction in growth parameters and yield of sorghum. This reduction was lesser under irrigation with use of water partially neutralized for RSC amended with gypsum and sulphuric acid.

REFERENCES

AOAC. 2005. *Official Methods of Analysis.* 18th edn. Association of Official Analytical Chemists. Arlington, VA, USA.

Bajwa, M.S., Singh, N.T., Randhawa, N.S. and Brar, S.P.S. 1975. Under ground water quality map of Punjab state. *Journal of Research (PAU)***12**: 117–122.

Ghafoor, A., Murtaza, G., Ahmad, B. and Boers, T.M. 2008. Evaluation of amelioration treatments and economic aspects of using saline-sodic water for rice and wheat production on salt-affected soils under arid land conditions. *Irrigation and Drainage* **57**: 424–434.

Ghafoor, A., Murtaza, G. and Qadir, M. 2001. Gypsum: Economical amendment for amelioration of saline-sodic waters and soils for improving crop yield. *Presented at National*. *Workshop on Agricultural Use of Gypsum*. April 09–10, 2001, LRRI, NARC, PARC, islamabad, Pakistan

Kumar, A. and Chhabra, R. 1996. Effect of gypsum application on performance of vetiver (*Vetever iazizaniodes*) grass in a highly alkali soil. *Indian Journal of Agronomy* **41**(3): 465–467.

Kumar, A., Sharma, P.C. and Batra, L. 2006. Effect of alkali water irrigation and gypsum doses on yield and chemical composition of oat (*Avena sativa*) varieties in an alkali soil. *Indian Journal of Agronomy* **51**(1): 70–72.

Lotovitskii, P.S. and Bilai, V.A. 2001. Effect of chemical ameliorants on the chemistry of surface water used for irrigation. *Water Research* **28**(4): 451–460.

Minhas, P.S. and Bajwa, M.S. 2001. Use and management of poor quality waters for the rice–wheat based production system. *Journal of Crop Production* **4**(1): 273–306.

Murtaza, G., Ghafoor, A., Owens, G., Qadir, M. and Kahlon, U.Z. 2009. Environmental and economic benefits of saline-sodic soil reclamation using low-quality water and soil amendments in conjuction with a rice-wheat cropping system. *Journal of Agronomy and Crop Science* **195**: 124–136.

Oster, J.D. and Grattan, S.R. 2002. Drainage water reuse. *Irrigation and Drainage Systems* **16**: 297–310.

Page, A.L., Miller, R.H. and Kenny, D.R. 1982. Methods of soil analysis–Part I and II. *American Society of Agronomy*, Madison, WI, USA.

Singh, R., Singh, B. and Singh, V. 1994. Effect of RSC in irrigation water on *Citronella jawa* under different levels of fertilizers. *Journal of the Indian Society of Soil Science* **42**: 164–166.

Qadir, M. and Schubert, S. 2002. Degradation processes and nutrient constraints in sodic soils. *Land Degradation & Development* **13**: 275–293.

Venkata Rao, P., Lakshmi, G.V. and Latha, M. 2014. High RSC irrigation water effects on growth, yield attributes and yield of rice in coastal Andhra Pradesh. *International Journal of Research in Chemistry and Environment* **4**(4): 10–14.

Vision 2050. 2013. ICAR-*Indian Grassland and Fodder Research Institute, Jhani, Uttar Pradesh*. pp. 6.

Yadav, R.K., Kumar, A., Lal, D. and Batra, L. 2004. Yield responses of winter (*rabi*) forage crops to irrigation with saline drainage water. *Experimental Agriculture* **40**(1): 65–75.

Yadav, R.K., Singh, S.P., Lal, D. and Kumar, A. 2007. Fodder production and soil health with conjunctive use of saline and good quality water in semi-arid region. *Land Degradation & Development* **18**(2):153–161.