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Management of Sodic Water for Radish Seed Production and their Effect on Chemical Properties of Soil

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ABSTRACT: Irrigation water is one of the most critical and scarce resource for vegetable production in arid and semiarid regions of India. The lack of good quality water supply for irrigation is now becoming a major issue that forcing the farmers to use low quality water. Keeping view, a field trial was conducted for two years at Research Field of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar. The experiment consisted of three levels of farmyard manure (0, 10 and 20 t/ha) and gypsum (0, 50 and 100% neutralization of RSC water with gypsum) laid out in factorial RBD with three replications. The application of farmyard manure and gypsum individually and in combination significantly influenced the soil pH, electrical conductivity, exchangeable sodium percentage at harvest time, and seed yield per plant and per hectare of radish crop. The treatment where farmyard manure was applied at the rate of 20 t/ha in combination with 100% neutralization of RSC water through gypsum (10 t/ha) was obtained significantly maximum seed yield per plant (g), seed yield (q/ha), soil pH, electrical conductivity and exchangeable sodium percentage from 0-15 cm depth.

Keywords: Radish, Seed yield, pH, EC, ESP, FYM, Gypsum, Sodic water.

INTRODUCTION

Radish (*Raphanus sativus* L.) is a popular root vegetable in both tropical and temperate regions belongs to *Brassicaceae* family. Radish is grown for its young tender modified root (fusiform), which develops as primary root from hypocotyls consumed either cooked, or raw (Shrestha and Thapa, 2018). India is second largest producer of vegetables, next to China, however, their productivity is far less than the world average. One of the main reasons behind low productivity of vegetables may be the use of poor quality water for irrigation. Scarcity of good quality surface as well as ground water is the main constraint for success of agriculture in most of the arid and semi-arid regions of the country. Further, the ground water is either saline or alkaline and almost 60% of it as such is not suitable for irrigation. Simultaneously, vegetable production including radish is being threatened by increasing soil salinity or alkalinity particularly in irrigated areas, which provide 40% of the world food (FAO, 2001). Sodic water is characterized by its less EC (<4 dSm^{-1}), high SAR (>10 mmol/L) and high RSC (>2.5 me/L), which may constitute most important source of supplemental irrigation provided it is used judiciously and carefully. In the arid and semi-arid tracts of Haryana on an average about 37% groundwater is good, 8% is marginal and 55% is poor in quality. Out of poor quality water, 11%, 18% and 26% are sodic, saline and saline-sodic, respectively (Singh *et al.*, 2004). The continuous use of sodic water for irrigation as such causes soil salinization, sodification and adversely effects on growth, seed yield and quality of the crops.

Electrical conductivity and sodium play a key role in the suitability of water for irrigating the crops. Irrigation water should not contain any salts since their higher concentration in irrigation water increases the soil osmotic pressure and affects the soil structure, which reduces infiltration capacity of the soil. The salts in irrigation water remain behind in the soil as water evaporates or is used by the crop. Salinity problem develops if salts accumulate in crop root zone to a concentration, which causes a great loss in crop yield (Pandian *et al.*, 2016). Kaur *et al.* (2008) reported that long term sodic water irrigation may adversely affect quality of seed, soil and microbial biomass carbon along with some physico-chemical properties of soil. Although, during emergency such water could be used with special management practices depending upon the rainfall, crop to be grown and soil type. Good quality seed is also one of the important means to increase production and productivity in any seed crop. Hence, the experiment was conducted to study the effect of FYM and gypsum on chemical properties of soil and seed yield of radish irrigated with sodic water.

MATERIALS AND METHODS

The experiment was carried out for two years (2017-18 and 2018-19) at Vegetable Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar situated at 29°10' North latitude and 75°46' East longitude at mean elevation of 215.2 meter above mean sea level. The soil of the experimental field was sandy loam with 19.6% clay and cation exchange capacity 9.3 C mol/kg in 0-30 cm depth, soil field capacity 16.88%, permanent wilting point 7.98%, bulk density 1.57 g/cc and electrical conductivity 0.48 dSm^{-1}. The soil was low in organic carbon (0.42%), available nitrogen (125 kg ha^{-1}) and medium in available phosphorus (16 kg ha^{-1}). The experiment consists of nine treatments comprising of three levels of farmyard manure (0, 10 and 20 t/ha) and three levels of gypsum (0, 50 and 100% neutralization of RSC water with gypsum) laid out in a randomized block design (factorial) replicated three times. For neutralization of 50% of RSC of irrigation water 5.0 t/ha gypsum and for 100% neutralization 10.0 t/ha gypsum was applied.

The data were recorded from five randomly selected plants from each treatment of each replication. The observations thus recorded were averaged for computation on per plant basis *viz*., seed yield per plant (g), seed yield (q/ha), soil pH, EC and ESP at planting and at harvest. For the estimation of seed yield per plant, the mature pods at brownish stage were picked from five tagged plants. The seed was extracted from the harvested pods after drying properly and then converted in gram seed yield per plant. Seed yield (q/ha): The seed obtained from the entire plants in a plot including the tagged plants from each plot on net plot basis was weighed separately to calculate the seed yield per plot in kilogram and later it was converted into seed yield per hectare in quintal per hectare.

Ionic analysis. The ionic analysis techniques used are given in Table 1 and their composition and analysis of irrigation water and soil during the course of experimentation was carried out in soil laboratory of the Department of Soil Science and Agricultural Chemistry, CCS HAU, Hisar are presented in Table 2.

Carbonates and bicarbonates: These ions were determined by titration with standard H_2SO_4 using phenolphthalein and methyl orange as indicators (Richards, 1954). Calcium and magnesium: Versenate (EDTA) method of Cheng and Bray (1951) was followed for the determination of Ca and Mg. Sodium and potassium: Sodium and potassium ions were estimated with the help of flame photometer (Richards, 1954).

Soil analysis. The soil samples were collected from every experimental plot with the help of soil auger from a depth of 0-15 cm. The soil samples were then air dried and ground with wooden pestle and mortar to pass through a 2 mm stainless steel sieve. The exchangeable sodium percentage (ESP) and residual sodium carbonate (RSC) were computed by following the formulas of U.S. Salinity Laboratory Staff (1954).

Soil pH: The soil pH was determined in 1:2 soil-water suspensions by using glass electrode pH meter (Jackson, 1973). pH = -log10 (H^+) = log ($1/aH^+$). Electrical conductivity: EC of the soil saturation extract was measured by using Conductivity Bridge and results were expressed as dSm^{-1} at 25°C temperature (Jackson, 1973). Residual sodium carbonate (me/litre): it is calculated by Versenate (EDTA) and titrimetric method. The calculated formula is (CO_3^{2-}+ HCO_3^-) – (Ca^{2+}+ Mg^{2+}). Soil ESP: Exchangeable sodium was extracted by 1 N ammonium acetate (pH 7.0) and estimation was determined by using flame photometer (Richards, 1954).

$$\text{ESP} = \frac{\text{Exchangeable Na+}}{\text{Total of Cation Exchange Capacity (CEC)}} \times 100$$

Table 1: Ionic and soil analysis techniques.

Parameters	Techniques/Methods	References
pH	pH meter	1:2 soil water suspension (Jackson, 1973)
EC (dSm^{-1})	Conductivity meter	Jackson, (1973)
Exchangeable sodium percentage	IN ammonium acetate and using flame photometer	Richards, (1954)
Na & K	Flame photometry	Richards, (1954)
Ca & Mg	Versenate (EDTA)	Cheng and Bray, (1951)
Cl, CO_3^{2-} & HCO_3^-	Titrimetric method	Richards, (1954)

Table 2: Ionic composition and quality parameters of irrigation water.

Ion/Parameter	Values (me/litre)
CO_3^{2-}	0.7
HCO_3^-	13.8
Ca^{2+}	0.5
Mg^{2+}	1.5
Na^+	15.8
RSC_{iw}	12.5

Note: CO_3^{2-} = Carbonate, HCO_3^- = Bicarbonate, Ca^{2+} = Calcium, Mg^{2+} = Magnesium, Na^+ = Sodium, RSC_{iw} = Residual sodium carbonate of irrigation water, me/litre = Milliequivalents per litre.

The statistical analysis of data collected during the study was done by applying the technique of analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984) and Panse and Sukhatme (1961). All the statistical analysis was carried out by using OPSTAT statistical software. The critical difference for all the characters was calculated to compare the means of two treatments with the help of standard error for the differences of two treatments mean and tabulated value of 't' at 5 per cent level of significance and at error degree of freedom. The critical difference was calculated by multiplying SE d with t value at 5% error degree of freedom.

RESULT AND DISCUSSION

A. Seed Yield

Application of FYM and gypsum individually as well as in combinations significantly influenced the radish seed yield irrigated with sodic water (Table 3). Among the farmyard manure, significantly maximum seed yield per plant (22.89 g) and seed yield (4.99 q/ha) was obtained under the F_2 treatment where FYM was applied 20 t/ha as compared to control. Whereas, among the gypsum levels, significantly maximum seed yield per plant (23.26 g) and seed yield per hectare (4.85 q) was registered with G_2 treatment, where gypsum 10 t/ha was applied and minimum under the G_0 treatment, where no gypsum was applied.

Among the interaction effect, meaningfully maximum seed yield per plant (26.46 g) and seed yield (6.62 q/ha) were obtained in the treatment F_2G_2 where farmyard manure was applied at the rate of 20 t/ha along with 100% neutralization of RSC of irrigation water through gypsum (10 t/ha) followed by F_2G_1 (where 20 t/ha farmyard manure with 50% neutralization of RSC by gypsum 5 t/ha) and minimum in F_0G_0 treatment, where no farmyard manure and gypsum was applied. The yield and yield attributes increase with the combined application of farmyard manure and gypsum because, it might be due to that gypsum minimizes the adverse effect of sodic water and farmyard manure improve the physico-chemical properties of soil. The present results conform to the findings of Tripathi *et al.* (2013); Singh *et al.* (2013); Vithwel and Kanaujia (2013); Kumar *et al.* (2017); Kaswan *et al.* (2013); Kumar *et al.* (2019).

B. Chemical Properties of Soil

The chemical properties of soil in relation to FYM and gypsum application irrigated with sodic water are given in Table 3. The ominously minimum soil pH (7.95 and 7.68), soil EC (0.49 and 0.46) and soil ESP (19.43 and 19.0) at planting and at harvest, respectively, were noticed under the treatment F_2, where 20 t/ha farmyard manure was applied and maximum in the treatment where no farmyard manure was applied. Among gypsum application, significantly minimum soil pH at planting and at harvest (7.75 and 7.53), soil EC (0.54 and 0.51) and soil ESP (12.52 and 11.97) at planting and at harvest, respectively, were observed with the G_2 treatment, where 10 t/ha gypsum was applied and maximum under the G_0 treatment, where no gypsum was applied.

Table 3: Response of different levels and interaction effect between FYM and gypsum on chemical properties of soil and seed yield of radish (pooled data of 2017-18 & 2018-19).

Treatments	Seed yield per plant (g)	Seed yield (q/ha)	Soil pH at planting	Soil pH at harvest	Soil EC at planting	Soil EC at harvest	Soil ESP at planting	Soil ESP at harvest
Farmyard manure								
F_0	15.34	2.40	8.58	8.52	0.93	0.92	22.93	22.80
F_1	19.61	3.57	8.38	8.20	0.58	0.56	20.47	20.02
F_2	22.89	4.99	7.95	7.68	0.49	0.46	19.43	19.0
SEm±	0.09	0.010	0.05	0.04	0.014	0.015	0.53	0.44
CD (p=0.05)	0.28	0.029	0.16	0.13	0.042	0.044	1.58	1.32
Gypsum								
G_0	14.23	2.06	9.12	9.05	0.81	0.80	37.08	36.98
G_1	20.34	4.04	8.05	7.82	0.65	0.63	13.23	12.87
G_2	23.26	4.85	7.75	7.53	0.54	0.51	12.52	11.97
SEm±	0.09	0.010	0.05	0.04	0.014	0.015	0.53	0.44
CD (p=0.05)	0.28	0.029	0.16	0.13	0.042	0.044	1.58	1.32
Interaction effect								
F_0G_0	12.19	1.32	9.35	9.55	1.0	1.01	42.13	42.90
F_0G_1	14.62	2.61	8.35	8.10	0.94	0.92	13.60	13.05
F_0G_2	19.20	3.26	8.05	7.90	0.85	0.83	13.05	12.45
F_1G_0	13.61	2.17	9.05	8.85	0.77	0.75	35.50	34.85
F_1G_1	21.09	3.86	8.15	7.95	0.54	0.52	13.25	13.05
F_1G_2	24.13	4.68	7.95	7.80	0.42	0.40	12.65	12.15
F_2G_0	16.89	2.69	8.95	8.75	0.65	0.63	33.60	33.20
F_2G_1	25.31	5.66	7.65	7.40	0.47	0.45	12.85	12.50
F_2G_2	26.46	6.62	7.25	6.88	0.34	0.31	11.85	11.30
SEm±	0.16	0.017	0.09	0.07	0.024	0.026	0.91	0.76
CD (p=0.05)	0.48	0.050	0.27	0.22	0.073	0.077	2.74	2.29

F_0= No farmyard manure, F_1= 10 t/ha farmyard manure, F_2= 20 t/ha farmyard manure; G_0= No gypsum, G_1= 50% of gypsum requirement, G_2= 100% of gypsum requirement

Among the interaction effect, significant minimum soil pH (7.25 and 6.88), soil EC (0.34 and 0.31) and soil ESP (11.85 and 11.30) at planting and at harvest, respectively, were noticed under the F_2G_2 treatment, where farmyard manure 20 t/ha in combination with 100% neutralization of residual sodium carbonate water by gypsum was applied. The soil pH, EC and ESP decreased significantly with the increasing levels of farmyard manure and gypsum. The decrease in pH, EC and ESP with gypsum application was due to the removal of Na^+ ions from the exchange complex by those of Ca^+ ions introduced in the system by the dissolution of gypsum applied. Significantly decrease of soil pH, EC and ESP due to farmyard manure could be attributed to preferential adsorption of divalent cations, particularly Ca^+ ion. The depth wise gradient of ESP could be due to the evapo-transpiration effects leading to higher concentration of salts in the top layer. Similar results were obtained by Choudhary *et al.* (2007); Kaur *et al.* (2008); Singh *et al*. (2013); Kumar *et al*. (2017).

CONCLUSION

Thus, it is concluded that F_2G_2 treatment combination where farmyard manure was applied at the rate of 20 t/ha along with 100% neutralization of residual sodium carbonate water through gypsum is effective in increased the seed yield of radish and improved soil pH, Electrical conductivity (EC), Exchangeable sodium percentage (ESP) during both of the years of 2017-18 and 2018-19.

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Conflict of Interest. None.

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