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Effect of sodic water irrigation on yield and cation composition of vetiver (*Vetiveria zizanioides* (L.) Nash.)

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Abstract

The effect of residual sodium carbonate in irrigation water on the yield and cation composition of vetiver (*Vetiveria zizanioides*) was studied in open bottom reinforced concrete cemented cylindrical barrels embedded in the field at Lucknow, India. While shoot and root yields of vetiver were not significantly affected with residual sodium carbonate in irrigation water, oil yield significantly decreased at the residual sodium carbonate concentration of 8 mel^{-1} and above as compared to control (tube well water). The concentration of sodium was about 10 times higher in the root than in shoot tissues. The great ability of vetiver to limit sodium entry in shoot tissues and maintain sufficient potassium and calcium concentration at high residual sodium carbonate concentration indicate that it is a tolerant to sodic stress.

Key words : sodic water irrigation, sodicity tolerance, *Vetiveria zizanioides*, yield.

Abbreviations

RSC	:	Residual sodium carbonate
ECe	:	Electrolyte conductivity in soil saturation extract
SARe	:	Sodium adsorption ratio in soil saturation extract

In many arid and semi-arid regions the continual use of sodic water for irrigation causes excessive accumulation of exchangeable sodium in soils and adversely affects crop productivity. Singh *et al.* (1994a) and Singh *et al.* (1994b) reported that herb yield of aromatic grasses such as palmarose (*Cymbopogon martinii* (Roxb.) Wats.) and Java citronella (*Cymbopogon winterianus* Jowitt.) decreased with increase in sodicity of irrigation water. Vetiver (*Vetiveria zizaniodes* L. Nash.) is a high valued crop for its aromatic roots and its essential oil has a great demand in cosmetic, perfume and pharmaceutical industries. The crop has been reported to withstand high soil pH and water logging (Khosoo 1987) whereas, Sethi *et al.* (1976) reported that its root and oil yield were adversely affected with soil salinity. We report the effect of sodic

water (residual sodium carbonate) irrigation on growth, yield and cation composition of vetiver in this paper.

The experiment was conducted during 1993-95 in open bottom reinforced concrete cemented (RCC) cylindrical (125 cm length x 50 cm diameter) barrels embedded in the field to a depth of 100 cm at the Experimental Farm of the Central Institute of Medicinal and Aromatic Plants, Lucknow. The climate of the area is semi-arid with a mean annual precipitation of 650 mm and about 80% of the rainfall is received during the monsoon seasons (June to September). The Ap horizon (0-15 cm) of Typic Ustifluvent was collected from the adjacent field and 280 kg of soil was filled in each barrel. The soil was compacted to attain a bulk density of 1.3 g cm^{-3}. The soil was sandy loam in texture with pH 8.2, EC 0.17 dS m^{-1}, organic carbon 1.5 g kg^{-1} and available N (alkaline permangnate extractable), P (Olsen-P) and K (N NH_4OAC extractable) 54, 3 and 42 mg kg^{-1} soil, respectively. All the barrels received uniform basal dose of 4.3 g N, 0.9 g P and 1.8 g K through urea, single superphosphate and muriate of potash, respecively.

A slip of vetiver (cv. KS-1) was transplanted in each barrel during August 1993. After the crop established with the monsoon rains it was subsequently irrigated with sodic water of RSC 2 (control: tube well water), 4, 8, 12 and 16 mel^{-1}. At each irrigation 50 mm of water was applied whenever the cumulative pan evaporation minus rainfall reached 75 mm. Irrigation water of different RSC were prepared by dissolving the requisite quantity of Nacl, Na_2SO_4, $NaHCO_3$ and $CaCL_2$. $2H_2O$ with tube well water (EC 0.74 dSm^{-1}; RSC 2 mel^{-1}). The electrolyte conductivity (EC) of the sodic waters of RSC 2 (tube well water) 4, 8, 12 and 16 mel^{-1} were 0.74, 3.5, 3.4, 3.0 and 2.9 dSm^{-1}, respectively. The SAR values of tube well water (control) and simulated sodic waters (RSC 4 to 16 mel^{-1}) were 1.5 and 12.5, respectively. The crop received 800 mm of sodic water during the entire growth period in addition to 783 mm rainfall. The cumulative pan evaporation during the growth period of the crop was 1983 mm. The treatments were replicated four times in a completely randomized design.

The crop was harvested after 18 months of transplanting and roots and shoots were separated. The roots were washed free of soil particles, air dried and weighed. Essential oil content in the air dried roots were determined by hydrodistillation on Clevenger's apparatus. Essential oil yields were computed by multiplying root yields by the essential oil content in tissue. The plant samples were thoroughly washed with distilled water, oven dried (65°C) to constant weight, ground and digested in tri- acid mixture of HNO_3: H_2SO_4: $HClO_4$ (10:1:4-v:v:v). Calcium and magnesium in the digest were estimated by versanate method and sodium and potassium contents were determined by flame photometry (Jackson 1973). The soil samples were collected from each barrel at the end of the experiment and different characteristics were determined by the methods outlined by Richard (1954).

At the end of experiment, a soil pH of 8.5, 8.7, 9.2, 9.3 and 9.3 were developed by the use of sodic water irrigation or RSC 2 (tube well water) 4, 8, 12 and 16 mel^{-1}, respectively. These soil pH values correspond to SAR values of 3.1, 16.4, 18.1 22.8 and 24.7, respectively in soil

saturation extract. Significant changes in soil pH and SAR with increase in RSC in irrigation water are obvious in the study.

The shoot and root yields of vetiver were not significantly affected with the RSC content in irrigation water (Table 1). Khosoo (1987) also observed its exceptionally higher tolerance of soil sodicity and water logging as compared to the other medicinal and aromatic crops. The oil yield of vetiver slightly increased with increase in RSC from 2 mel^{-1} (control) to 4 mel^{-1} and thereafter the oil yield decreased significantly with further increases in RSC. The oil yield was reduced by 33.1, 37.1 and 52.9% over control at 8, 12 and 16 mel^{-1} RSC, respectively. A significant reduction in oil yield might be attributed to decrease in oil content at high salinity and sodicity build up with the continual use of sodic water irrigation. A similar observation has been reported by Sethi (1976) where high salinity adversely affected oil yield of vetiver.

The sodium (Na) concentration in the shoot increased significantly with an increase in RSC from 2 mel^{-1} (control) to 4 mel^{-1} and thereafter it decreased with increase in RSC to 8 mel^{-1} (Table 2). Further increases in RSC had no effect on Na concentration. The Na concentration in root tissue gradually increased with increase in RSC of irrigation water, however the increase in Na was pronounced only with RSC 4 mel^{-1}. The concentration of potassium (K) in shoot increased with increase in RSC to 8 mel^{-1} but decreased with further increases in RSC. The K concentration in root decreased significantly with increase in RSC of irrigation water. The calcium (Ca) concentration remained constant in shoot while it increased in the root tissues with increases in RSC to 12 mel^{-1}. However, a significant decrease in calcium concentration was observed with RSC of 16 mel^{-1}. The magnesium (Mg) concentration increased with increase in RSC to 4 and 12 mel^{-1} in the shoot and root, respectively, but further increase in RSC decreased Mg concentration.

Vetiver had a great ability to limit the Na entry in shoot tissues at high RSC. This was evident from the higher K/Na and Ca/Na ratios in the shoots than that in the roots (Table 2). Sodicity of irrigation water had a significant effect on the ion balance in the plant but respond dissimilarly to RSC levels. The

Table 1. Effect of sodic water (residual sodium carbonate) irrigation on yield of vetiver

RSC level (mel^{-1})	Dry weight of shoot (kg/barrel)*	Root yield (kg/barrel)	Oil yield (ml/barrel)
2**	0.69	0.53	4.04
4	0.70	0.65	4.25
8	0.78	0.66	2.70
12	0.72	0.73	2.54
16	0.71	0.68	1.90
SEm (±)	0.07	0.08	0.53
CD (P=0.05)	NS	NS	1.63

* 125 cm x 50 cm size
** Control - tube well water

Table 2. Effect of sodic water (residual sodium carbonate) irrigation on cation compositon of vetiver

RSC level (mel^{-1})	Na^+ (%)		K^+ (%)		Cz^{2+} (%)		Mg^{2+} (%)		K^+/Na^+ (ratio)		Ca^{2+}/Na^+ (ratio)	
	A	B	A	B	A	B	A	B	A	B	A	B
2*	0.01	0.11	0.48	0.45	0.60	0.96	0.29	0.69	48.0	4.1	60.0	8.7
4	0.03	0.21	0.64	0.40	0.60	0.96	0.44	0.73	21.3	1.9	20.0	4.6
8	0.02	0.22	0.59	0.38	0.60	1.40	0.36	1.24	29.5	1.5	30.0	5.6
12	0.02	0.25	0.59	0.38	0.60	1.40	0.36	1.24	29.5	1.5	30.0	5.6
16	0.02	0.26	0.58	0.35	0.48	1.08	0.36	0.69	29.0	1.3	24.0	4.2
CD (P=0.05)	0.003	0.043	0.065	0.063	0.061	0.213	0.018	0.089	-	-	-	-

A = Shoot; B = Root
* Control - tube well water

K/Na and Ca/Na ratios decreased markedly with an increase in RSC from 2 (control) to 4 mel^{-1} and thereafter it did not follow a specific trend with further increases in RSC. At RSC 4 mel^{-1}, the absorption of Na was relatively higher and lower than that of Ca and K. Conversely at high RSC (>4 mel^{-1}), the absorption of Ca and K was more than that of Na. Salt tolerance of crops is related to their ability to control Na absorption and maintain sufficient K and Ca concentrations (Beke & Volkmar 1995). In this experiment, no significant changes in K/Na and Ca/Na ratios under high RSC indicates that vetiver is tolerant to sodic stress.

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