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Effect of saline irrigation water on yield and bio-chemical parameters of leafy vegetables

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Abstract
An experiment was conducted at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Junagadh Agricultural University, Junagadh to study the effect of saline irrigation water on yield and bio-chemical parameters of leafy vegetables during the *Rabi* season of 2022-23 and 2023-24. Among the different leafy vegetable crops like coriander, fenugreek and spinach, significantly the highest yield, coriander equivalent yield, germination% and lowest Na/K ratio were observed with treatment combination saline irrigation water 2 dS/m with spinach crop and significantly higher chlorophyll content was recorded with irrigation water having EC<2 dS/m with fenugreek crop. Among the parameters under study, yield, coriander equivalent yield, germination%, plant height and chlorophyll content decreased and Na/K ratio and proline content increased with increase in salinity levels of irrigation water from 2 to 8 dS/m. While, significantly the highest proline content was observed when spinach crop irrigated with saline irrigation water having EC 8 dS/m. While, higher mean salinity index and mean seed yield, minimum yield decline at EC 8.0 dS/m and for 50% yield reduction at EC 8.02 dS/m, as well as lower Na/K ratio in seed and stalk were observed with spinach. Spinach crop found more salt tolerance as compared to coriander and fenugreek on the basis of salinity indices.

Keywords: leafy vegetable, salinity levels, bio-chemical parameters, proline, chlorophyll and yield

Introduction
Coriander (*Coriandrum sativum*) also called cilantro or Chinese parsley, feathery annual plant of the parsley family (Apiaceae), parts of which are used as both as herb and as spice. Spinach (*Spinacia oleracea*) is a leafy green flowering plant native to central and western Asia. It is of the family Amaranthaceae. Its leaves are a common edible vegetable consumed either fresh, or after storage using preservation techniques. Fenugreek (*Trigonellafoenum graecum*) is an annual plant belongs to the family Leguminoceae. It is the famous spices in human food. The seeds and green leaves of fenugreek are used in food as well as in medicinal application that is the old practice of human history.
In Saurashtra, region of Gujarat, the main source of irrigation is well/tubewell water and majority of these waters are either saline or sodic or both. However, the farmers of this region grow these leafy vegetables with this poor quality water to meet their requirement under such condition, the soil properties and crop yield are adversely affected, hence, cultivation of this crops are not economical. However, by selecting suitable leafy vegetables, it could be possible to harvest better crop yield.

Materials and Methods
The experimental soil was clayey in texture and alkaline in reaction with pH 8.14, EC 0.58 dS/m, ESP 5.24 (%) and SAR 3.30 (me/l). The experiment consists of 12 treatments combinations comprising four levels of salinity water *viz.* < 2, 4, 6 and 8 dS/m and three different leafy vegetables *viz.* C_1- Coriander (Variety GDLC-1), C_2-Fenugreek (Variety PEB) and C_3-Spinach-(Variety Local). Complete Randomized Design (Factorial) was used and treatments were repeated three time. Standard agronomic practices were adopted for raising healthy crop. In this study yield (g/plot), coriander equivalent yield (g/plot), germination%, plant height, plant Na/K ratio, chlorophyll content (µmol/m^2) and proline (µmol/g) content were

recorded. Proline content was determined by determination of free proline method developed by Bates *et al.* (1973) [4] and method was employed for the extraction of chlorophyll from leaf tissue without maceration (DMSO) given by Hiscox and Israelstam, (1979) [10].

Results and Discussion

Effect of different levels of saline irrigation water on yield and yield attributes

The data presented in Table-1 revealed that the application of irrigation water having EC < 2 dS/m gave significantly higher coriander equivalent yield (795 g/plot) in 2022-23, (940 g/plot), 2023-24 as well as in pooled results (867 g/plot). Significantly higher germination% (87.93), plant height (20.71cm) and chlorophyll content (57.05 µmol/m^2) were also reported with application of saline irrigation water having EC< 2 dS/m. While, significantly higher plant Na/K ratio (2.39) and proline content (0.173 µmol/g) were recorded with the application of irrigation water having EC-8 dS/m. Among the parameters under study, yield, coriander equivalent yield, germination%, plant height and chlorophyll content decreased and Na/K ratio and proline content increased with increase in salinity levels of irrigation water from 2 to 8 dS/m. Among the different leafy vegetable crops, spinach crop yielded significantly higher coriander equivalent yield (658, 719 and 689 g/plot) in 2022-23, 2023-24 as well as in pooled results, respectively. Significantly highest germination percentage (92.25%), plant height (28.09 cm) and proline content (0.182 µmol/g) were observed with spinach. Lowest Na/K ratio (1.22) was observed with coriander and highest chlorophyll content (57.71 µmol/m2) was observed with fenugreek (Table-2). Seed germination decrease with salinity stress; in fact, high salinity inhibits it by causing osmotic stress (preventing water uptake) and ionic toxicity (damaging enzymes and cellular components). Proline content increases during salinity stress in plants because it functions as an osmoprotectant, helping to maintain cell turgor and osmotic balance. It also acts as a cellular shield, stabilizing membranes and enzymes, scavenging free radicals, and providing a non-toxic nitrogen store. This multifaceted role helps the plant to survive and function under the damaging conditions of high salt concentrations.

Our findings also corroborated with the finding of Aymen & Cherif (2013) [3] and Poonam (2024) [15] demonstrating that saline stress reduced plant growth of coriander. According to Mergeb, *et al.* (2020) [12] the salinity reduced germination uniformity and germination synchrony in fenugreek plant. The growth and yield parameters (number of leaves, and fresh and dry weight) of spinach genotypes were significantly decreased with increasing the EC levels of saline water (Bhatti, *et. al.*, 2021) [5]. Salinity stress decreased shoot growth of fenugreek plants associated with leaf area and leaf number reduction (Hayet, 2019) [9]. Alaa El-Din *et al.* (2013) [1] reported that sodium chloride (NaCl) reduced seeds germination, plant length, number of leaves, plant strength, roots number and root length of coriander, while increasing the content of total soluble solids and proline.

Effect of salinity on soil parameter after harvest

The data given in Table-3 revealed that the significantly higher EC (1.61 dS/m), ESP (7.13%) and SAR (5.97) recorded with the application of saline irrigation water EC-8 dS/m. While, the lower value of EC (0.50 dS/m), ESP (5.08%) and SAR (3.20) recorded with the application of saline irrigation water having EC<2 dS/m. Effect of different crops on soil parameters under study were found non significant.

Interaction effect crop and salinity

Interaction effect of salinity and different crops was found significant with respect to yield, coriander equivalent yield, germination%, Na/K ratio in plant, chlorophyll content and prolien content in leaves. Significantly the highest yield (2017 g/plot), coriander equivalent yield (896 g/plot), germination% (94.00) and lowest Na/K ratio (0.69) were observed with treatment combination saline irrigation water 2 dS/m and spinach crop (Table 4 & 5) and significantly higher chlorophyll content (73.00 µmol/m^2) was recorded with irrigation water having EC<2 dS/m and fenugreek crop. While, significantly the highest proline content (0.287 µmol/g) was observed when spinach crop irrigated with saline irrigation water having EC 8 dS/m (Table 6). In a study, Keshavarzi *et al.* (2011) [11] found spinach plants sensitive to salinity and advised that the crop should not be cultivated in saline soils. In contrast, recent studies report no significant loss in spinach yield and nutritional value with saline water levels up to 9 dS/m (Ors and Suarez, 2016 and Ferreira *et al.*, 2018) [13, 8]. In another study, spinach yield was increased at EC levels of 4 and 7 dS/m and subsequently declined at EC 9.0 dS/m and above (Ors and Suarez, 2017) [14]. Similarly, Ferreira *et al.* (2020) [7] suggested the threshold level for spinach between 7 to 10 dS/m for water salinity, and from 5.6 to 8.9 dS/m for soil salinity

Salt tolerance criteria of different leafy vegetables

The data presented in Table-7 indicated that the highest mean seed yield (619.64 g/plot) was recorded with spinach crop followed by fenugreek (414.88 g/plot) and the lowest with coriander crop (248.00 g/plot). The mean salinity index (69.12%) was found the highest in spinach crop followed by fenugreek (48.31%). Reduction in yield at EC 8.0 (dS/m) over control was observed the lowest in spinach (52.87%) followed by fenugreek (64.21%) and the highest with coriander (79.26%). The spinach crop was found higher salt tolerant for 50% yield decline (at EC level of irrigation water 8.02 dS/m) as compared to other crops.

Table 1: Effect of salinity levels of irrigation water on yield of leafy vegetables

Treatment	Yield (g/plot)			Coriander equivalent yield (g/plot)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Crop						
Coriander	340	450	395	340	450	395
Fenugreek	668	788	728	483	583	533
Spinach	1481	1619	1550	658	719	689
SEm±	14.6	19.1	12.0	8.9	13.0	7.8
CD at 5%	43	56	34	26	38	22
Salinity levels (dS/m)						
S_1: 2.0 EC	1258	1437	1347	795	940	867
S_2: 4.0 EC	898	1026	962	515	609	562
S_3: 6.0 EC	674	802	738	381	467	424
S_4: 8.0 EC	489	544	517	282	323	303
SEm±	16.9	22.0	25.6	10.2	15.0	21.3
CD at 5%	49	64	73	30	44	61
Cx S						
SEm±	29.2	38.1	24.0	17.7	25.9	15.7
CD at 5%	85	111	68	52	76	45
CV%	6.10	6.93	6.60	6.22	7.68	7.13

Table 2: Effect of salinity on growth, yield distributes and quality parameter of leafy vegetable

Treatment	Germination%	Plant height (cm)	Plant Na/K ratio	Chlorophyll content (µmol/m^2)	Proline (µmol/g)
Crop					
Coriander	74.60	12.76	1.22	45.74	0.068
Fenugreek	90.29	13.68	2.16	57.71	0.111
Spinach	92.25	28.09	1.46	41.11	0.182
S.Em±	0.59	1.69	0.19	0.68	0.004
CD at 5%	1.66	4.79	0.55	1.92	0.012
Salinity levels (dS/m)					
S_1: 2.0 EC	87.93	20.71	0.83	57.05	0.072
S_2: 4.0 EC	87.06	19.10	1.36	50.89	0.097
S_3: 6.0 EC	86.25	17.31	1.87	45.12	0.141
S_4: 8.0 EC	81.61	15.59	2.39	39.68	0.173
S.Em ±	0.68	0.58	0.09	0.78	0.002
CD at 5%	1.92	1.64	0.27	2.22	0.006
Vx S	0.00	0.00	0.00	0.00	0.000
S.Em±	1.17	0.48	0.30	1.35	0.006
CD at 5%	3.33	NS	0.86	3.84	0.017
CV%	3.35	6.48	8.93	6.87	7.270

Table 3: Effect of salinity on soil parameter after harvest of leafy vegetable

Treatment	EC (dS/m)	pH	ESP	SAR (me/l)
Initial	0.58	8.14	5.24	3.30
Crop				
Coriander	0.92	8.19	6.02	4.63
Fenugreek	0.94	8.27	6.14	4.64
Spinach	0.95	8.29	6.25	4.69
SEm±	0.01	0.10	0.08	0.07
CD at 5%	NS	NS	NS	NS
Salinity levels (dS/m)				
S_1: 2.0 EC	0.50	8.20	5.08	3.20
S_2: 4.0 EC	0.60	8.25	5.74	4.40
S_3: 6.0 EC	1.03	8.27	6.60	5.05
S_4: 8.0 EC	1.61	8.28	7.13	5.97
S.Em ±	0.03	0.06	0.41	0.28
CD at 5%	0.08	NS	1.17	0.80
Vx S				
S.Em±	0.02	0.11	0.16	0.13
CD at 5%	NS	NS	NS	NS
CV%	6.31	3.17	6.55	7.03

Table 4: Interaction effect of different vegetable crops and salinity levels of irrigation water on yield and coriander equivalent yield

Treatment	Yield (g/plot)				Coriander equivalent yield (g/plot)			
	Coriander	Fenugreek	Spinach	Mean	Coriander	Fenugreek	Spinach	Mean
S_1: 2.0 EC	836	1189	2017	1347	836	870	896	867
S_2: 4.0 EC	347	732	1807	962	347	536	803	562
S_3: 6.0 EC	224	566	1426	738	224	414	634	424
S_4: 8.0 EC	173	426	951	517	173	312	422	303
Mean	395	728	1550		395	533	689	
	S.Em±	24.0			S.Em±	15.7		
	CD at 5%	68			CD at 5%	45		

Table 5: Interaction effect of different vegetable crops and salinity levels of irrigation water on germination% and Na/K ratio in plant

Treatment	Germination%				Na/K ratio in plant			
	Coriander	Fenugreek	Spinach	Mean	Coriander	Fenugreek	Spinach	Mean
S_1: 2.0 EC	76.6	93.2	**94.0**	87.9	0.72	1.09	0.69	0.83
S_2: 4.0 EC	77.3	91.8	92.1	87.1	0.90	2.02	1.16	1.36
S_3: 6.0 EC	76.8	88.9	93.0	86.3	1.45	2.54	1.62	1.87
S_4: 8.0 EC	67.8	87.2	89.9	81.6	1.82	2.98	2.36	2.39
Mean	74.6	90.3	92.3		1.22	2.16	1.46	
	S.Em±	1.17			S.Em±	0.30		
	CD at 5%	3.33			CD at 5%	0.86		

Table 6: Interaction effect of different vegetable crops and salinity levels of irrigation water on chlorophyll content and proline content

Treatment	Chlorophyll (µmol/m^2)				Proline (µmol/g)			
	Coriander	Fenugreek	Spinach	Mean	Coriander	Fenugreek	Spinach	Mean
S_1: 2.0 EC	53.57	73.00	44.57	57.05	0.053	0.080	0.084	0.072
S_2: 4.0 EC	45.24	65.17	42.27	50.89	0.065	0.098	0.129	0.097
S_3: 6.0 EC	43.50	51.60	40.27	45.12	0.069	0.124	0.229	0.141
S_4: 8.0 EC	40.64	41.07	37.34	39.68	0.087	0.144	0.287	0.173
Mean	45.74	57.71	41.11		0.068	0.111	0.182	
	S.Em±	1.35			S.Em±	0.006		
	CD at 5%	3.84			CD at 5%	0.017		

Table 7: Salt tolerance criteria based on yield

Crop	Mean coriander equivalent yield (g/plot)	Mean salinity index (%)	Reduction at EC 8.0 (dS/m) over control (%)	EC (dS/m) for 50% yield decline	Regression equation (Y= a + bX)
Coriander	248.00	29.66	79.26	4.78	Y = 922.8293 - 105.5551X R^2= 0.7995**
Fenugreek	414.88	48.31	64.21	6.09	Y = 969.5111 - 88.7322X R^2= 0.9027**
Spinach	619.64	69.12	52.87	8.02	Y = 1,086.6567 - 79.5627X R^2= 0.9611**

Conclusion

From the forgoing results, it can be concluded that Among the different leafy vegetable crops like coriander, fenugreek and spinach, higher mean salinity index (69.12) and mean seed yield (619.64 g/plot), minimum yield decline (52.87%) at EC 8.0 dS/m and for 50% yield reduction at EC 8.02 dS/m, as well as lower Na/K ratio in seed and stalk were observed with spinach. Spinach crop found more salt tolerance as compared to coriander and fenugreek on the basis of salinity indices.

References

1. Alaa El-Din SE, Samira O, Soad ES, Nagat T. Effect of salinity stress on coriander (*Coriandrum sativum* L.) seed germination and plant growth. Egypt Acad J Biol Sci. 2013;4(1):1-7.
2. Al-Saady NA, Khan AJ, Rajesh L, Esechie HA. Effect of salt stress on germination, proline metabolism and chlorophyll content of fenugreek (*Trigonella foenum-graecum* L.). J Plant Sci. 2012;7:176-185.
3. Aymen EM, Cherif H. Influence of seed priming on emergence and growth of coriander (*Coriandrum sativum* L.) seedlings grown under salt stress. Acta Agric Slov. 2013;101(1):41-47.
4. Bates LS, Waldren RP, Teare ID. Rapid determination of free proline for water-stress studies. Plant Soil. 1973;39:205-207.
5. Bhatti SM, Gadehi AK, Rajpar I, Kandhro MN, Soothar MK, Bughio ZR. Effect of saline water on growth, yield and ion content in spinach genotypes. J Innov Sci. 2021;7(1):78-87.
6. Ewas AS, El-Sharif SO, Tawfik N. Effect of salinity stress on coriander (*Coriandrum sativum*) seed germination and plant growth. Egypt Acad J Biol Sci. 2013;4(1):1-7.
7. Ferreira JFS, Da Silva Filho JB, Liu X, Sandhu D. Spinach plants favor the absorption of K^+ over Na^+ regardless of salinity and may benefit from Na^+ when K^+ is deficient in the soil. Plants. 2020;9(4):507-512.
8. Ferreira JFS, Sandhu D, Liu X, Halvorson JJ. Spinach (*Spinacia oleracea* L.) response to salinity: nutritional value, physiological parameters, antioxidant capacity, and gene expression. Agriculture. 2018;8(10):163-175.
9. Hayet BC, Alfonso A, Cristina MA, Francisco P, Ouzna AB. The growth impairment of salinized fenugreek (*Trigonella foenum-graecum* L.) plants is associated with changes in the hormonal balance. J Plant Physiol. 2019;212:311-319.
10. Hiscox JD, Israelstam GF. A method for the extraction of chlorophyll from leaf tissue without maceration. Can J Bot. 1979;57(12):1332-1334.
11. Keshavarzi MHB, Rafsanjani MO, Moussavinik SM, Abdin MZ. Effect of salt (NaCl) stress on germination and early seedling growth of spinach (*Spinacia oleracea* L.). Ann Biol Res. 2011;2(4):490-497.
12. Mergeb SO, Salah AA, Mohamed AO. Effect of NaCl salinity on germination of *Trigonella foenum-graecum*. Chem Res J. 2020;5(5):105-116.
13. Ors S, Suarez DL. Salt tolerance of spinach as related to seasonal climate. Hortic Sci. 2016;43(1):33-41.
14. Ors S, Suarez DL. Spinach biomass yield and physiological response to interactive salinity and water stress. Agric Water Manag. 2017;190:31-41.
15. Poonam Y. Salinity effect on morphological characteristics of Coriandrum sativum L. Int J Innov Res Eng Multidiscip Phys Sci. 2024;12(4):2349-7300.
16. Robinson SP, Downton WJS, Millhouse JA. Photosynthesis and ion content of leaves and isolated chloroplasts of salt-stressed spinach. Plant Physiol. 1983;73(2):238-242.
17. Saleh OM, Salah AA, Mohamed AO. Effect of NaCl salinity on germination of *Trigonella foenum-graecum*. Chem Res J. 2020;5(5):105-116.
18. Turhan A, Kuşçu H, Şeniz V. Effects of different salt concentrations (NaCl) on germination of some spinach cultivars. J Agric Fac Uludag Univ. 2011;25(1):65-77.
19. Turhan A, Kuscu H, Ozmen N, Asik BB, Serbeci MS, Seniz V. Alleviation of deleterious effects of salt stress by application of supplementary potassium and calcium on spinach. Acta Agric Scand B Soil Plant Sci. 2013;63(2):184-192.
20. Xu C, Mou B. Responses of spinach to salinity and nutrient deficiency in growth, physiology, and nutritional value. J Am Soc Hortic Sci. 2016;141(1):12-21.