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Sonali Chaudhari
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Navsari Agricultural University, Navsari, Gujarat, India

Bhikhabhai Talavia
Assistant Professor, Office of the Director Students' Welfare, Junagadh Agricultural University, Junagadh, Gujarat, India

Arpita Meena
M.Sc., Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
Sonali Chaudhari
Ph.D. Scholar, Dept. of Soil Science and Agricultural Chemistry, Navsari Agricultural University, Navsari, Gujarat, India

Effect of saline irrigation water on biochemical parameters of okra (*Abelmoschus esculentus* L.) varieties

Sonali Chaudhari, Bhikhabhai Talavia and Arpita Meena

Abstract
A pot experiment was conducted at Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh to assess the "Effect of saline irrigation water on biochemical parameters of okra (*Abelmoschus esculentus* L.) varieties" during the summer-2018. The pot experiment comprised of for levels of saline irrigation water (< 2.0, 4.0, 6.0 and 8.0 dS m^{-1}) and five genotypes of okra (Guj.Okra-2, Guj.Okra-3, Guj.Okra-5, Guj. Anand okra-6 and Pusa savani) by adopting Factorial CRD with three replications. The results indicated that the bio-chemical parameters like RWC, chlorophyll-a, chlorophyll-b and total chlorophyll were recorded significantly highest with salinity level S_1 (< 2.0 dS m^{-1}), whereas the proline accumulation recorded highest with S_4 (8.0 dS m^{-1}) at 45 DAS. In case of varieties, the proline content, RWC, chlorophyll-a, chlorophyll-b and total chlorophyll content at 45 DAS were recorded significantly highest with variety V_1 (Guj. Okra-2) as compare to other tested varieties of okra. The combine effect of variety and salinity found significant in respect of RWC, chlorophyll-a, chlorophyll-b, total chlorophyll, Na content in leaves at 45 DAS with variety V_1 (Guj. Okra-2) at salinity level S_1 (< 2 dS m^{-1}). The proline accumulation (1.68 µmole g^{-1}f.wt.) was found significantly highest with variety V_1 (Guj. Okra-2) and salinity level S_4 (8.0 dS m^{-1}).

Keywords: Chlorophyll content, okra**,** proline, RWC, salinity levels, varieties

Introduction

The quality of irrigation water plays a vital role in crop production but scarcity of good quality water is a major problem in arid and semi-arid regions. With increasing demand and decreasing supplies of good quality water, the farmers are bound to use underground water, which is generally brackish. It is estimated that about 10 million hectares of irrigated land is abandoned every year in entire world mainly due to secondary salinization and sodication as well as its emerging consequence of the adverse effects of irrigation. The importance of water in these areas is so great that it seems no other way except harnessing the available poor quality ground waters by adopting suitable technology.

Plant growth is either depressed or entirely prevented due to excessive build-up of salinity in soil due to irrigation with saline water. In addition to the osmotic stress, crop productivity is adversely affected due to specific ion toxicities, inadequate nutrient availability and cationic imbalances within the plants. These soils, which are underlain with poor quality ground waters in the arid and semi-arid regions tested with low in organic matter and always remains poor in fertility (Bajwa *et al.,* 1998) [3]. Therefore, the importance of judicious management of irrigation water in these soils is as important for their reclamation point of view.

The negative effects of salinity have been attributed to increase in Na^+ and Cl^- ions in different plants hence these ions produce the critical conditions for plant survival by intercepting different plant mechanisms. Both Na^+ and Cl^- are the major ions which produce many physiological disorders in plants; Cl^- is the most dangerous (Tavakkoli *et al.,* 2010) [18]. The outcome of these effects may cause membrane damage, nutrient imbalance, altered levels of growth regulators, enzymatic inhibition and metabolic dysfunction, including photosynthesis which ultimately leads to plant death.

Okra (*Abelmoschus esculentus* L.) is herbaceous hairy annual plant of the mallow family (Malvaceae). It is native to South Asian, Ethiopian and West African origins. Okra is one of the important summer vegetable crop also known as gumbo or ladies' fingers. It is a good source of minerals, vitamins and fiber.

Although salinity stress has been reported to adversely affect the growth and productivity of okra, it is considered a semi tolerant or moderately tolerant crop compared with many other vegetable crops (Maas and Hoffman, 1977) [9].

High levels of salinity have multiple adverse effects at the later growth stages of the crop life cycle. The morphology, physiology and metabolism of okra including the activities of various enzymes are adversely affected due to high levels of salinity and crop yield is reduced (Abid *et al.*, 2002) [1].

Materials and Methods

A pot experiment was conducted during summer-2018, to study the "Effect of saline irrigation water on biochemical parameters of okra (*Abelmoschus esculentus* L.) varieties" at the Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh. The soil of the experimental plot was clayey in texture and alkaline in reaction with pH 7.47, EC 0.82 dS m^{-1}. The soil was low in available nitrogen (203.84 kg ha^{-1}), medium in available phosphorus (41.04 kg ha^{-1}), high in available potassium (434.51 kg ha^{-1}), high in available sulphur (29.50 kg ha^{-1}), low in available iron (3.25 mg kg^{-1}), high in available zinc (0.55 mg kg^{-1}), medium in available manganese (5.20 mg kg^{-1}) and high in available copper (1.25 mg kg^{-1}). The treatment consists of four levels each of salinity (2, 4, 6 and 8 dS m^{-1}) and and five varieties (Guj. Okra-2, Guj.Okra-3, Guj.Okra-5, Guj. Anand Okra-6 and pusa savani) by adopting Factorial CRD with three replications. The required quantity of N: P_2O_5: K_2O at the rate of 100:60:50 kg ha^{-1} were dissolved in water and then applied to all the pots as basal through urea, DAP and MOP, respectively. Ten seeds of okra were sown in each pot at a depth of 2 to 3 cm on the 16^{th} February 2018. Only the required quantity of water was applied to avoid leaching during first and second irrigations. A week after germination, ten plants per each pot was maintained under normal practices. The irrigation to each pot was given as per requirements throughout the growing season by mixing the sea water and tap water. The composition of saline water contain EC 58.9 dS m^{-1}, pH 7.98, Na 839.13 meq l^{-1}, K 4.72 meq l^{-1}, Ca+Mg 114.8 meq l^{-1}, CO_3 1.4 meq l^{-1}, HCO_3 1.9 meq l^{-1} and Cl 540 meq l^{-1}. The pots were uniformly irrigated as and when crop required irrigation throughout the growing season. All the other management practices were adopted in these crops as per the recommendations. Fully developed leaves of five plants from each pot were collected at 45 DAS of crop. These leaves samples sun dried and then oven dried at 60 °C for 24 hrs. Then, each samples were powdered by use of pestle and mortar and utilized for determination of biochemical parameters like proline (Bates *et al.* 1973), RWC (Richard and Gail, 1974) and chlorophyll (DMSO by Hiscox and Israelstam, 1979) [7].

Result and Discussion

The data on "effect of saline irrigation water on biochemical parameters of the okra (*Abelmoschus esculentus* L.) Crop" are presented in table-1.

Table 1: Effect of salinity and varieties on biochemical parameters in leaves of okra at 45 DAS

Treatments	Proline (µmole g^{-1}f.wt.)	RWC (%)	Chlorophyll-a (Mg g^{-1}f.wt.)	Chlorophyll-b (Mg g^{-1}f.wt.)	Total chlorophyll (Mg g^{-1}f.wt.)
Salinity level (S) dS m^{-1}					
S_1 - < 2.0 (tap water)	0.52	79.69	4.70	1.82	6.52
S_2 - 4.0	0.78	77.77	4.27	1.55	5.82
S_3 - 6.0	0.95	75.83	2.89	0.93	3.82
S_4 - 8.0	1.22	73.91	1.38	0.47	1.85
S.Em.+	0.02	0.51	0.04	0.02	0.05
C.D. (P=0.05)	0.04	1.45	0.12	0.04	0.14
Variety (V)					
V_1- Guj. Okra-2	1.16	79.09	4.16	1.83	5.99
V_2- Guj. Okra-3	0.82	76.36	3.28	1.06	4.34
V_3- Guj. Okra-5	0.60	75.50	2.50	0.71	3.21
V_4- Guj. Anand okra-6	1.02	77.48	3.58	1.45	5.03
V_5- Pusa savani	0.72	75.57	3.03	0.91	3.94
S.Em.+	0.02	0.57	0.05	0.02	0.06
C.D. (P=0.05)	0.05	1.62	0.14	0.05	0.16
S × V Interaction					
S.Em.+	0.03	1.13	0.10	0.04	0.11
C.D. (P=0.05)	0.10	NS	0.27	0.10	0.32
C.V.%	6.86	2.55	5.02	5.10	4.27

Effect of salinity

The proline content increased with increasing salinity levels of irrigation water. Significantly the higher proline (1.22 µmole g^{-1}f.wt.) content was recorded under application of 8.0 dS m^{-1} (S_4) level of saline irrigation water. Proline is multifunctional amino acids and also acting as a plant growth regulator. Proline preferred as a common osmolyte in plants and get up-regulated against different stresses. Its accumulation in plants provides protection against salinity and drought stress. Proline accumulation in salt stressed plants is a primary defense response to maintain the osmotic pressure in a cell, which is reported in salt tolerant and salt sensitive cultivars of many crops (Misra and Gupta, 2005) [11]. These results are supported by Sairam *et al*. (1998) [14], Parvi and Satyawat (2008) [12] and Saleem *et al*. (2011) [15] in okra and also by Chookhampaeng *et al.*, (2008) [5] in tomato.

Application of 2.0 dS m^{-1} (S_1) saline irrigation water gave significantly the higher value of RWC (79.69%). The RWC decreased with increased salinity levels of irrigation water. This may be due to the salt stress caused negative effect on water uptake in plant (Sheldon *et al*. 2004) [17]. The valuation of chlorophyll-a content of okra leaves at 45 DAS decreased with increasing levels of salinity of irrigation water. Significantly the highest chlorophyll-a content (4.70 mg g^{-1} f.wt.) was recorded under 2.0 dS m^{-1} (S_1) saline irrigation water. This may be due to the reduction of chlorophyll content under high salt stress condition in the leaves which might be due to membrane deterioration of the cell membrane of the chloroplast leading towards lesser accumulation of chlorophyll and lesser photosynthetic efficiency as reported by (Seeman and Critchley 1985). Similar results were finding by Jamil *et al*. (2012) in rice, Saleem *et al*. (2011) [15] in okra and also Hajer *et al*. (2006) [6] and Manan *et al*. (2016) [10] in tomato plant.

Result revealed that chlorophyll-b content decreased with an increasing salinity levels. The highest chlorophyll-b (1.82 mg g^{-1} f.wt.) observed in salinity level (S_1) 2.0 dS m^{-1}. In general, decrease of these pigments under salt stress is considered to be a result of slow synthesis or fast breakdown of the pigments in cells (Ashraf and Neilly, 1987) [2].

The total chlorophyll (6.52 mg g^{-1} f.wt.) which was recorded higher under application 2.0 dS m^{-1} (S_1) level of saline irrigation water. Result revealed that total chlorophyll content decreased with an increasing salinity levels. Similar results were finding by Manan *et al*. (2016) [10] in tomato plant.

Effect of variety

The results showed that the proline content in leaves was significantly affected by different varieties at 45 DAS. Significantly the highest proline content (1.16 µmole g^{-1} f. wt.) was observed in variety V_1 (Guj. Okra-2) as compared to other varieties of okra. This might be due to tolerance of the variety to salinity. The proline accumulation in various variety was found in order of $V_1 > V_4 > V_2 > V_5 > V_3$.

Different varieties of okra significantly influenced on the relative water content of okra leaves which was recorded higher in variety V_1 (Guj. Okra-2) with value of 79.09% which remain statistically at par with V_4 (Guj. Anand Okra-6). RWC directly reflects the water status of plants and its reduction indicated that salinity resulted in water deficit in plants. The negative effect on plant water relations was induced by an increase in soluble salts which might have decreased the uptake of water and nutrients due to osmotic effects and toxicity as suggested by Yang *et al.* (2009) [19].

Significantly the highest chlorophyll-a (4.16 mg g^{-1} F.WT.), chlorophyll-b (1.83 mg g^{-1} f.wt.) and total chlorophyll content (5.99 mg g^{-1} f.wt.) of okra leaves at 45 DAS was recorded in variety V_1 (Guj. Okra-2). The chlorophyll content of okra was observed in decreasing order of $V_1 > V_4 > V_2 > V_5 > V_3$.

Interaction Effect of salinity and variety

The combined effect of salinity and variety was significantly affected on proline accumulation with salinity level S_4 (8.0 dS m^{-1}) in variety Guj. Okra-2 (V_1). The RWC content did not significantly influenced by interaction effect of different levels of saline irrigation water and different varieties of okra at 45 DAS of crop. The combined effect of saline irrigation water and variety on chlorophyll a (5.48 mg $gf.wt^{-1}$) chlorophyll b (2.62 mg $gf.wt^{-1}$) and total chlorophyll (8.10 mg $gf.wt^{-1}$) content was found significantly highest under salinity level S_2 (< 2.0 dS m^{-1}) with variety V_1 (Guj. Okra-2).

Table 2: Interaction effect of salinity and varieties on proline (µmole g^{-1} F.WT.) content in leaves of okra at 45 DAS

	S_1 - < 2.0 dS m^{-1} (Tap Water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1- Guj. Okra-2	0.75	0.94	1.30	1.68	1.16
V_2- Guj. Okra-3	0.53	0.79	0.82	1.16	0.82
V_3- Guj. Okra-5	0.30	0.62	0.66	0.82	0.60
V_4- Guj. Anand okra-6	0.55	0.83	1.22	1.51	1.02
V_5- Pusa savani	0.47	0.74	0.76	0.91	0.72
Mean	0.52	0.78	0.95	1.22	
S.Em.±	0.03		C.D. (P=0.05)	0.10	

Table 3: Interaction effect of salinity and varieties on chlorophyll-a (mg g^{-1} F.WT.) content in leaves of okra at 45 DAS

	S_1 - < 2.0 dS m^{-1} (Tap Water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1- Guj. Okra-2	5.48	4.81	3.78	2.55	4.16
V_2- Guj. Okra-3	4.54	4.35	2.95	1.29	3.28
V_3- Guj. Okra-5	4.04	3.65	1.58	0.72	2.50
V_4- Guj. Anand okra-6	5.08	4.48	3.31	1.45	3.58
V_5- Pusa savani	4.33	4.08	2.85	0.88	3.03
Mean	4.70	4.27	2.89	1.38	
S.Em.±	0.19		C.D. (P=0.05)	0.27	

Table 4: Interaction effect of salinity and varieties on chlorophyll-b (mg g^{-1} F.WT) content in leaves of okra at 45 DAS

	S_1 - < 2.0 dS m^{-1} (Tap Water)	S_2 - 4.0 dS m^{-1}	S_3 - 6.0 dS m^{-1}	S_4 - 8.0 dS m^{-1}	Mean
V_1- Guj. Okra-2	2.62	2.29	1.79	0.62	1.83
V_2- Guj. Okra-3	1.56	1.52	0.72	0.46	1.06
V_3- Guj. Okra-5	1.29	0.82	0.42	0.32	0.71
V_4- Guj. Anand okra-6	2.36	1.69	1.19	0.56	1.45
V_5- Pusa savani	1.39	1.32	0.52	0.39	0.91
Mean	1.84	1.53	0.93	0.47	
S.Em.±	0.04		C.D. (P=0.05)	0.10	

Table 5: Interaction effect of salinity and varieties on total chlorophyll (mg g^{-1} F.WT) content in leaves of okra at 45 DAS

	S_1 - < 2.0 dS m^{-1} (Tap Water)	**S_2 - 4.0 dS m^{-1}**	**S_3 - 6.0 dS m^{-1}**	**S_4 - 8.0 dS m^{-1}**	**Mean**
V_1- Guj. Okra-2	8.10	7.10	5.57	3.17	5.99
V_2- Guj. Okra-3	6.06	5.90	3.67	1.74	4.34
V_3- Guj. Okra-5	5.33	4.47	2.00	1.04	3.21
V_4- Guj. Anand okra-6	7.44	6.17	4.50	2.00	5.03
V_5- Pusa savani	5.66	5.47	3.37	1.27	3.94
Mean	6.52	5.82	3.82	1.85	
S.Em.±	0.11		C.D. (P=0.05)	0.32	

Conclusion

On the basis of results with forgoing discussion, it can be concluded that the okra variety Guj. Okra-2 showed significantly higher values bio-chemical parameters (proline, RWC, chlorophyll-a, chlorophyll-b and total chlorophyll) over the salinity level. However, Guj. Okra-2 and some extent Guj. Anand Okra-6 should be suggested for cultivation of salinity affected areas. Whereas salinity level S_1 (< 2.0dS m^{-1}) which were noted acceptable for irrigation of okra crop with some extent with salinity level S_2 (4.0 dS m^{-1}). The tolerance order of okra varieties to salinity in decreasing order of Guj.Okra-2 > Guj.Anand Okra-6 > Guj.Okra-3 > Pusa savani > Guj.Okra-5 against salinity in silty clay soil.

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