IMPACT OF SALINITY ON GROWTH, YIELD AND WATER USE EFFICIENCY OF *MOMORDICA CHARANTIA* L. UNDER RAISEDBED IRRIGATION

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ABSTRACT

The study was conducted at the experimental field of Faculty of Agricultural Engineering, Sindh Agriculture University Tandojam during the year 2013, with the hypothesis that saline water can successfully be used for growing bitter gourd (*Momordica charantia* L) in soil and climatic conditions of Sindh. In this study, the saline water was used with raised bed furrow irrigation method and the soil texture was silt loam. The randomized complete block design (RCBD) with four treatments (I_1, I_2, I_3 and I_4) and three replications was laid in the study. I_1 was fresh water, I_2, I_3 and I_4 water were with ECw 3dS/m, ECw 4dS/m and ECw 5dS/m respectively. The seeds were sown on both sides of ridge at a depth of 2-3 cm. Plant to plant distance of 40-45 cm was maintained. Irrigation media was prepared by mixing NaCl for required ECw in drums then applied to the experimental plots. The interval among each irrigation was kept 7 days. The experiment results revealed that, the average soil ECe increased 0.09, 0.57, 0.96 and 1.47dS/m in I_1, I_2, I_3 and I_4 respectively. pH decreased as 0.2 with I_1, I_2, I_3 treatments and 0.3 with I_4 treatment. The infiltration rate (cm/h) and porosity (%) were increased, thus the dry density (g/cm^3) of soil profile decreased. The average yield of bitter gourd was obtained 11.47, 9.65, 7.92and 6.76 kg with treatments I_1, I_2, I_3 and I_4, respectively, thus the yield of crop was decreased as 15.84%, 30.95% and 41.07% with treatments I_2, I_3 and I_4 (saline water) when compared to treatments with freshwater (I_1) irrigation. Agronomical data were observed decreasing with the increasing ECw of the irrigation water. The crop water productivity (CWP) for treatments I_1, I_2, I_3 and I_4 was found 3.07, 2.58, 2.12 and 1.81 kg/m^3, crop water productivity decreased with use of saline water. The present study suggests that farmers can use saline water having ECw ≤ 5dS/m for the bitter gourd at reduction of 41% (approximately) of the production.

Key-words: Salinity, water efficiency, yield, bitter gourd.

INTRODUCTION

The scarcity of good quality irrigation water is a serious problem in arid and semi-arid areas of the world which include one third of the earth. Freshwater resources are very scarce, just 3% of the total earth supplies water from which 1% freshwater and 2% ice water reserves for agricultural purpose and left behind 97% water in Sea is extremely saline and not suitable for large amount utilization in agriculture. More than half of the world's groundwater supply have also turned saline (FAO, 2003).

The surface and groundwater quality is deteriorating day by day. The indiscriminate discharge of industrial and domestic waste water into open water bodies and groundwater is the main threat to the Pakistan water reserves (Kahlown and Majeed, 2002). In arid and semi-arid regions, commercial agriculture is mainly dependent on the easily available good quality irrigation water. Fresh surface water supplies in these areas are slowly becoming short to meet the crop water requirement.

Soil salinity is one of the large spread environmental stresses that impose serious threat to the germination, plant growth and yield. Crop yields start declining when pH of the soil solution exceeds 8.5 or EC cost goes higher than 4 dS/m. At higher EC values the crop yield are reduced so significantly that crop cultivations is not economical without soil amendments. Addition of salt to water, lower its osmotic potential, resulting in decreased availability of water to root cells (Sairan, 2002).

The cultivation of crops with increased salt tolerance and the adoption of new crop and water management strategies enhance and facilitate the use of saline waters for irrigation and crop production, while maintain soil salinity from becoming excessive (Rhoades *et a*l., 1992).

There is a critical need to develop methods to use low quality water and degraded land to boost the agricultural productivity (Bilquees and Khan, 2003). Agriculture production with saline irrigation water has been extended significantly in the last decade. It is usually accepted about 10% irrigated area are affected by salinity (Dinar, 2009).

Raised bed planting system is used since time immemorial by farmers in various parts of the world (Govaerts *et al*., 2007). About 90% of irrigated lands around the world are irrigated by furrow irrigation method and furrow irrigation needs less energy (Tiercelin and Vidal, 2006). Furrow irrigation method conserves water, as it applies water only down to the depths required to refill the root zone and especially handy in cases where there is water shortages (Jenny, 2008).

Momordica charantia L. has been used for centuries in the ancient traditional medicine of India, China, Africa, and Latin America. It possesses anti oxidant, anti microbial, anti viral, anti diabetic activities, also have the resistance to thrive in saline water having EC 6-8 dS/m and gives good percentage of yield up to EC 4-5 dS/m (Raman and Lan, 1996). Cucumber family is moderately tolerant and bitter gourd belongs to this family. Moderately tolerant crops resist ECw from 4 dS/m to 9 dS/m (OFWM, 1999). Thus keeping in view the importance and benefits of bitter gourd a research study was formulated to assess the effect of saline water on the growth, yield, and water-use efficiency by employing raised bed irrigation method.

MATERIALS AND METHODS

The research was conducted at the field of Sindh Agriculture University Tandojam on a plot of 130.5 m^2 (14.5 m x 9.0 m). The experimental setup was randomized complete block design (RCBD) with four treatments (Table 1, I_1 to I_4) and three replications. The whole plot was divided into twelve sub-plots of each size (3.0 m x 2.5 m). The width and length of each ridge were kept 1.5 m and 3.0 m, respectively in each sub-plot.

The soil samples were collected from the experimental field and analyzed in the laboratory of the Department of Land and Water Management, Faculty of Agricultural Engineering, Sindh Agriculture University Tandojam. Thirty six soil samples from twelve sub plots were collected at the soil depths 0-20 cm, 20-40 cm and 40-60 cm. The soil samples were analyzed then for EC, pH, soil texture, dry density, porosity and infiltration rate before sowing and after harvesting the bitter gourd.

Table 1. Treatment Amount of NaCl (g/L) mixed for required ECw.

Treatment	**EC_w (dS/m)**	**NaCl (g/L)**	**NaCl (g/drum)**
I_1	< 1.5	00	00
I_2	3	0.68	156.40
I_3	4	1.02	234.60
I_4	5	1.38	317.40

The experimental plots were deep ploughed and then pulverized using disc harrow. Then, two furrows were constructed manually. Width and length of each ridge were kept 1.5 m and 3.0 m, respectively in each sub-plot. The effect of different ECw of irrigation water was determined by growing bitter gourd.

The Hybrid variety of bitter gourd was sown for the experiment. The seed was sown on both sides of ridge at a depth of 2-3 cm. Plant to plant distance of 40-45 cm was maintained. After germination of seed the extra plants were thinned out to maintain the required distance between the plants.

Before the seedbed preparation, a pre- soaking irrigation of 10.2 cm was applied. Seedbed was prepared after the soil reached the field capacity. The crops were sown on a well prepared seedbed. The crop was irrigated at the required depth of 7.62 cm per irrigation, interval was 7 days (Palada and Chang, 2003), until the crop attained physiological maturity. Usually, irrigation frequency was reduced when the fruits reach near maturity and completely stopped in the last stage of harvest (Chandy, 2005). The quantity of irrigation water was estimated with volumetric method using following relationship:

Volume of water (m^3) = Length of furrow x width of furrow x depth of water
Where;
Length of furrow = 3.0 m
Width of furrow = 0.5 m
Depth of water = 0.0762 m
Hence the volume of water per furrow per irrigation was calculated as 0.1143 m^3. There were two furrows in each plot hence total volume of water per plot per irrigation was 0.2286 m^3

Fertilizers Application

Like other cucurbitaceous crops, bitter gourd also respond healthy to manure and fertilizer application. The dose of fertilizer depends upon the soil type, climate and type of cultivation. Generally, farmyard manure (25 tons/ha) was applied at the time of last ploughing. In addition, fertilizers 90 kg urea, 190 kg super phosphate and 100 kg muriate of potash per ha were also added. Half the dose of urea (45 kg) was applied 45 days after sowing (Chandy, 2005).

Crop Picking

Picking of each plot was done at 4-5 days interval manually, when crop attained the maturity. The picking process was continued throughout the crop period.

Water Use Efficiency

Crop water productivity on per hectare basis was determined by using following relation:

$$\mathbf{CWP} = \frac{\mathbf{Y_h}}{\mathbf{TW}}$$

Where;
CWP = Crop water productivity (kg m^3)
Yh = Total crop yield (kg/ha)
TW = Total irrigation water used for crop production (m^3/ha)

RESULTS AND DISCUSSIONS

Crop yield and growth

The results of yield with freshwater (I_1) are matching with Chandy (2005) who reported the yield of bitter gourd with normal freshwater 15000 kg per hectare (approximately). The experimental results of the crop yield were similar to Yaohu *et al*. (2010).The data given in Table 4 reveals that average weight of fruit with treatment I_1 was 62.30 g, whereas it was 50.10 g with I_2, 41.70 g with I_3 and 34.50 g with I_4. The weight of the fruit irrigated with fresh water was greater than those irrigated with saline water. The experimental observations were similar to those given by Yaohu *et al*. (2010). They observed that fruits irrigated with saline water with ECw ≤4.0 dS/m were heavier and were lighter in weight than the fruits irrigated with ≥4 dS/m. In Table 4, the average length of fruit with I_1 was measured 17.10 cm whereas it was 15.25 cm with treatment I_2, with 1_3, 13.40 cm and remains 11.46 cm with I_4. The length of the fruit irrigated with fresh water was greater than those irrigated with saline water. The experimental observations were similar to those given by Yaohu *et al.* (2010). They observed that plants irrigated with saline water with ECw ≤4.0 dS/m were the tallest and those irrigated with ≥4 dS/m were the shortest. Salt accumulation in the leachate was much greater with 4 dS/m than with 1 or 2 dS/m. In table 4,the average diameter of fruit with I_1 was 4.71 cm whereas it was 4.15 cm with treatment I_2, 3.75 cm with I_3 and 3.26 cm with I_4. The experimental observations were similar to those given by Yaohu *et a*l. (2010). They observed that saline water irrigation was affected on the size of fruit i.e. length and diameter. Maliwal (1997) reported that plant growth; shoot dry weight, root length and root dry weight of Kharchia-65, J-405 decreased with increasing salinity.In table 6 the crop Productivity was 3.07 kg/m^3, 2.58 kg/m^3, 2.12 kg/m^3 and 1.81 kg/m^3 with treatments I_1, I_2, I_3 and I_4 respectively. The experimental calculations were similar to those calculations by Yaohu *et al*. (2010) calculated irrigation water use efficiency (WUE), by dividing the total yield of waxy maize by the total quantity of irrigation water, was the relation between yield and quantity of irrigation water. Results showed that the crop water use efficiency decreased significantly with saline water irrigation.

Table 2. Crop yield in different irrigation treatments.

Treatments	**Yield (kg/plot)**			**Average**	**Yield (kg/ha)**
	R_I	**R_{II}**	**R_{III}**		
I_1	12.00	11.30	11.10	11.47±0.5	15,278.95
I_2	9.60	9.65	9.70	9.65±0.5	12,858.30
I_3	8.10	7.80	7.85	7.92±0.5	10,548.69
I_4	7.10	6.92	6.25	6.76±0.5	9,003.03

Table 3. Increase/decrease (%) in crop yield in different irrigation treatments.

Treatments	Average yield (kg/plot)	Average yield (kg/ha)	Decrease (%)
I_1	11.47±0.5	15,278.95	100.00
I_2	9.65±0.5	12,858.30	-15.84
I_3	7.92±0.5	10,548.69	-30.95
I_4	6.76±0.5	9,003.03	-41.07

Table 4. Average agronomical data of bitter gourd fruit in different irrigation treatments.

S.NO	Treatments	Weight (g)	Length (cm)	Diameter (cm)
1	I_1	62.30±5	17.10	4.71
2	I_2	50.10±5	15.25	4.15
3	I_3	41.70±5	13.40	3.75
4	I_4	34.50±5	11.46	3.26

Table 5. Irrigation water applied to the experimental field.

S.NO	Date of irrigation	Quantity of irrigation water (m^3)	
		Per plot	Per hectare
1	26/06/2013 (soaking dose)	0.3060	407.73
2	03/07/2013	0.2286	304.60
3	10/07/2013	0.2286	304.60
4	17/07/2013	0.2286	304.60
5	24/07/2013	0.2286	304.60
6	31/07/2013	0.2286	304.60
7	07/08/2013	0.2286	304.60
8	14/08/2013	0.2286	304.60
9	21/08/2013	0.2286	304.60
10	28/08/2013	0.2286	304.60
11	04/09/2013	0.2286	304.60
12	11/09/2013	0.2286	304.60
13	18/09/2013	0.2286	304.60
14	25/09/2013	0.2286	304.60
15	02/10/2013	0.2286	304.60
16	09/10/2013	0.2286	304.60
	Total	**3.7350**	**4976.76**

Table 6. Water use efficiency (kg/m^3) in different irrigation treatments.

Treatments	Total water per hectare (m^3)	Yield (kg/ha)	CWP (kg/m^3)
I_1	4976.76	15,278.95	3.07
I_2	4976.76	12,858.30	2.58
I_3	4976.76	10,548.69	2.12
I_4	4976.76	9,003.03	1.81

Soil Physical Properties

Table 7. Texture of soil of the experimental field.

S. No	Treatments	Clay %	Silt %	Sand %	Textural class
1	I_1	15	50	35	Silt loam
2	I_2	22	57	21	Silt loam
3	I_3	16	52	32	Silt loam
4	I_4	25	55	25	Silt loam

Table 8. Average infiltration rate, dry density and porosity of the soil profile pre and post experiment.

S. No	Treatments	Infiltration rate (cm/hr)		Dry density (g/cm^3)		Porosity (%)	
		Pre	Post	Pre	Post	Pre	Post
1	I_1	0.89	0.95	1.45	1.33	44.10	46.02
2	I_2	0.90	0.94	1.46	1.30	44.17	46.51
3	I_3	0.90	0.95	1.45	1.32	43.93	46.16
4	I_4	0.90	0.95	1,46	1,34	43.92	46.23

Soil chemical properties

Table 9. ECe of the soil profile pre and post experiment.

Soil Depth (cm)	EC_e(dS/m)							
	I_1		I_2		I_3		I_4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0-20	0.61	0.63	1.02	1.25	0.88	1.69	1.44	2.56
20-40	0.42	0.65	0.54	1.22	0.77	1.66	0.69	2.47
40-60	0.63	0.67	0.37	1.15	0.55	1.72	0.88	2.39
Mean	**0.56**	**0.65**	**0.64**	**1.21**	**0.73**	**1.69**	**1.00**	**2.47**

Table 10. pH of the soil profile pre and post experiment.

Soil Depth (cm)	I_1		I_2		I_3		I_4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0-20	8.5	8.4	8.5	8.3	8.3	8.2	8.3	8.0
20-40	8.5	8.3	8.4	8.2	8.4	8.2	8.2	7.9
40-60	8.4	8.1	8.4	8.2	8.3	7.9	8.2	7.8
Mean	**8.5**	**8.3**	**8.4**	**8.2**	**8.3**	**8.1**	**8.2**	**7.9**

Effect of saline irrigation water on soil physical properties

The Infiltration rate of soil profile increased after experiment with increasing EC of the irrigation water in all treatments with respect to soil depths. These results are related to those given by Nikos *et al*. (2003) they report that the water is held tighter to the soil in saline environments, the presence of salt in the water cause plants to use more energy extracting water from the soil. The key point is that excess salinity in soil water can reduce plant available water and cause plant stress. In table 8, the dry density of the soil decreasing after experiment with low quality irrigation water at all depths of the every plot. It was 1.45 g/cm^3 and 1.46 g/cm^3 and became 1.33 g/cm^3 and 1.31

g/cm^3. This may be because of continuous supply of irrigation water reduced the dryness of soil. The results of the experiment are similar to those reported by Kazman *et al*. (1983); Sheinberg and Letey (1984). They all observed that the dry density of the soil decreased on the top layer with saline water treatments and increased with depth infact, the high ESP value and the formation of a surface crust due to a high sodium content caused dispersion of the clay soil with the consequent formation of fine pores and high dry density.Table 8 showed that the porosity (%) of the soil profile increased after experiment with all treatments fresh as well as saline at all soil depths. This may be because of irrigation of water to the field maximized the pores of soil resulted increase in percentage of porosity. Quirk (1986) reported that sodium causes the deterioration and flocculation of the clay colloids resulted increase in porosity (%) of soil profile.

Effect of saline irrigation water on soil chemical properties

The data given in table 9 shows that ECe of the soil was 0.56 dS/m, 0.64 dS/m, 0.73 dS/m and 1.00 dS/m with I_1, I_2, I_3 and I_4 respectively. In I_2, I_3 and I_4 the saline water having ECW of 3, 4 and 5 dS/m was directly used through raised bed irrigation system, the ECe of the soil increased as 0.65 dS/m, 1.21 dS/m, 1.69 dS/m and 2.47 dS/m with treatments I_1, I_2, I_3 and I_4 respectively. The ECe of the soil increased 0.09, 0.57, 0.96 and 1.47 dS/m with treatments I_1, I_2, I_3 and I_4 respectively post experiment. The ECe of soil increased may be because of adsorption of salt on soil particles due to application of saline irrigation water. These results are similar to those reported by Wenjun *et a*l. (2007) and Gandahi *et al*, (2009). They concluded that average ECe values of soil irrigated with saline water were higher than the ECe values of soil irrigated with fresh water. Saline water irrigation increased soil salinity. The fluctuation of ECe was greater in the upper soil layers than in the lower soil layers.

On the otherhand the pH of the soil decreased with all treatments and their depths shown in Table 10. The average pH of the soil decreased 0.2 with I_1, I_2, I_3 treatments and 0.3 with treatment I_4 post experiment. Results are similar to Gandahi *et al*. (2009). They reported that decrease in pH of soil with increase of EC of irrigation water. It may be because the saline water used for study was prepared by adding sodium chloride in fresh water.

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