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Effect of blending fresh-saline water and discharge rate of drip on plant yield, water use efficiency (WUE) and quality of tomato in semi arid environment

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The use of alkali ground water constitutes a major threat to irrigated agriculture in semiarid parts of India. The entire arid and semiarid region in India is characterized by low rainfall and has the problems either of water scarcity or poor quality ground water and it can be better utilized for irrigation through drip irrigation system. An experiment was conducted on tomato crop at Central Institute of Post Harvest Engineering and Technology (CIPHET) Abohar, Punjab to study the effect of blending fresh and saline irrigation water on yield and quality. The good quality canal water (EC of 0.38 dS/m) and ground water (EC 19.5 dS/m) were mixed in ratio of 100% Fresh (F), 75:25 (Fresh: saline; F:S) and 50:50 (F:S). The irrigation was done through drip system with three discharge rates (1.2, 2.4 and 4.2 lph) at three irrigation levels of 0.6, 0.8 and 1.0. The plant yield decreased significantly with increase in salinity levels of irrigation water (that is, increase in proportion of saline water). The maximum plant yield (3.55 kg/plant) was recorded with fresh water irrigation while 50% saline water blending in irrigation produced the lowest yield (2.64 kg/plant). The average yield decreased significantly when the discharge rate of emitters increased from 1.2 to 2.4 lph. The quality of tomato is observed inferior in saline water treatment compared to fresh water treatment. The TSS and acidity of tomato fruits increased with increase in the saline water ratios of irrigation water. As compared to 100% fresh water treatment, the mixing of 75% fresh and 25% saline water reduced tomato yield by 11% and gave a better quality tomato fruits at the discharge rate 2.4 lph and irrigation level 0.8. Hence, saline water can be utilized through drip system for sustainable yield and quality tomato production in water scarce area having poor quality ground water.

Key words: Saline water, drip irrigation, tomato, quality.

INTRODUCTION

Water scarcity is becoming one of the major limiting factors for sustainable agriculture in the semi-arid regions of the world. In India the entire arid and semiarid regions have been characterized by low rainfall and have the problems either of water scarcity or poor quality ground water. The use of alkaline ground water possesses a major threat to plant growth and health, which is mostly observed in semiarid parts especially, south Asia (Minhas and Bajwa, 2001). In India, the regions identified for poor quality water are major parts of Rajasthan, Gujrat, Haryana, North Western UP and South Western parts of Punjab. Around 30 to 50% such type of lands are found

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Table 1. Physio-chemical properties of experimental soil.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Initial EC (dS/m)	pH	Bulk density (/cm^3)
0-15	76.57	8.02	15.41	0.15	8.52	1.69
15-30	77.92	7.69	15.39	0.13	8.63	1.71
30-45	78.21	7.35	14.44	0.13	8.70	1.82
45-60	76.96	8.36	14.68	0.14	8.70	1.79
60-90	78.28	8.18	13.54	0.15	8.63	1.76

in semiarid parts, where annual rainfall is 500 to 700 mm whereas, it is most intensively cultivated areas of the Indo-Gangetic plains. Oster and Jaiwardhane (1998) reported that soil properties such as permeability and availability of soil nutrients are adversely affected by irrigation with sodic water in these regions. Poor quality water constitutes 32 to 84% of ground water surveyed in different parts of India is related either saline or alkali (Minhas, 1996). Farmers of these regions are compelled to use poor quality water to irrigate their crops due to inadequate availability of good quality water. In South western Punjab, the quality of underground water is marginal and unfit for irrigation. About 22% ground water is fit, 31% marginal and 47% water is unfit for irrigation due to poor quality. Brackish groundwater with high EC (0.2 to 12.6 dSm^{-1}) and RSC ranging from 0.3 to 35.1 mel^{-1} has been observed in this zone (Jain and Kumar, 2007). Saline water up to 11 dS m^{-1} has been used successfully for commercial irrigation for a number of crops globally (Rhodes et al., 1992). However, in order to assure maximum yields from crops irrigated with saline water, it is necessary to develop special management procedures (Pasternak and De Malach, 1994). Presently, drip irrigation is widely regarded as the most promising irrigation system to use saline water (Meiri and Plantz, 1985). Several factors contribute to the good results obtained with saline water irrigation using drip irrigation (Dasberg and Or, 1999): (i) less water use (high application efficiency) results in less salt deposited on the field, (ii) avoidance of leaf burn, (iii) high frequency drip irrigation prevents the soil from drying out between irrigation events, thereby avoiding peaks in salt concentration and concomitant high osmotic potentials and (iv) salts are continuously leached out from the wetted section and accumulate at the wetting front away from the active root zone.

Keeping the aforementioned facts in view, the present investigation was planned with the aim to develop appropriate management practices for using saline water in conjunction with fresh water through drip system to grow tomatoes successfully in semi arid environment.

MATERIALS AND METHODS

Experimental site

A field experiment was conducted in sandy loam soil during 2008 to 2009 at research farm of Central Institute of Post Harvest Engineering and Technology (CIPHET), Abohar, Punjab, India. Abohar is located at southwestern part of Punjab (30° 4′ N and 74° 21′ E and mean sea level of 185 m). The climate of Abohar is semi-arid with severe summer and winter having the average annual rainfall is 300 to 400 mm. The soil type at the experimental site is sandy loam. The physico-chemical properties of soil at different depths are given in Table 1. The field capacity (1/3 atm) and wilting point (15 atm) of soil at 0 to 30 cm depth were found to be 13.30 and 3.52%, respectively on dry weight basis.

The canal (fresh) and tubewell (saline) water were both available at experimental site. The fresh water was used from the water tank constructed at CIPHET, Abohar farm. The groundwater in the CIPHET farm was saline in nature. The same saline water was pumped for mixing with fresh water and made three different salinities of water. The EC of Fresh canal water and 100% saline water was 0.38 and 19.5 dS/m, respectively. The quality of water after blending fresh canal and saline water in different ratios is given in Table 2. One tank of 2000 lit capacity was used for preparing mixture of fresh and saline water as per given ratio and then this mixed water was transferred to storage tank. The Na^+ and Cl^- ions present in fresh water were 1.6 and 1.0 meq/l, respectively. The Na^+ and Cl^- ions present in 100% saline water were 29.12 and 107.0 meq/l, respectively. The sodium adsorption ratio (SAR) of fresh irrigation water and 100 % saline water was 1.46 and 5.02, respectively.

Nursery raising and treatments

Nursery of tomato (*Lycopersicon esculentum* Cv GC 1500) was raised by sowing the seeds on raised beds in a plastic greenhouse (to protect seedlings from cold weather). Transplanting was done after 45 days and seedlings were transplanted after hardening in 5 m^2 plots with the spacing of 75 × 30 cm. Cultural practices (pest and disease control, weeding and fertigation) were carried out as per the guidelines given from Punjab Agricultural University (PAU), Ludhiana. Fertilizer application per hectare was done at the rate of 50 kg N, 62.5 kg P_2O_5 and 62.5 kg K_2O. Fifty percent of N and full dose of P and K were applied before the transplanting and the remaining 50% nitrogen fertilizers applied in 10 splits through fertigation.

The experimental plots were irrigated with three levels of saline water which was prepared by mixing different ratios of fresh (F) and saline (S) water. The resulted irrigation water's EC of different mixing ratios was found to be 0.38 (T_1), 6.3 (T_2) and 9.1 (T_3) dS/m for the mixing ratios of 100% F, 75:25 (F:S) and 50:50 (F:S), respectively. Initially, after transplanting equal quantities of fresh water were applied to all treatment plots in respect of irrigation levels for proper establishment of seedlings. After establishing the seedlings, fresh water was applied to all plots in three irrigation levels 0.6 (I_1), 0.8 (I_2) and 1.0 (I_3) IW/CPE ratios with three discharge rates of 1.2 (Q_1), 2.4 (Q_2) and 4.2 (Q_3) lph. To avoid water stress on plants due to high salinity of water and cold weather condition in early stage after transplanting, the irrigation treatments

Table 2. Characteristics of water used for irrigation.

Blending water ratio (F:S)	Ec (dS/m)	pH	HCo_3^-	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+	SAR
			me/l						
100 : 0	0.38	7.51	2.00	1.00	1.60	0.80	1.60	0.17	1.46
75 : 25	6.30	7.66	3.00	30.50	7.00	12.00	12.24	0.49	3.97
50 : 50	9.10	7.77	3.00	46.50	9.20	19.80	14.40	0.64	3.78
0 : 100	19.50	7.79	4.00	107.00	20.60	46.60	29.12	1.09	5.02

F= Fresh canal water; S = tube well saline water.

Figure 1. View of experimental field with low tunnels during winter.

with mixed water was started at the end of winter season after 45 days of transplanting. During the winter, the plants were covered with polyethylene film making as low tunnel to avoid the plants from frost injury during January to mid February (Figure 1) and polyethylene film was removed during daytime when sunshine occurs (Figure 2). The volume of irrigation water applied per plant through drip irrigation was estimated on the basis of plant spacing, pan evaporation, pan factor and crop coefficient. The irrigation was scheduled when cumulative pan evaporation (CPE) was 10 mm. Based on discharge capacity of emitters, the drip system was operated for determined time to apply given volume of water per plant in each irrigation level. Plant height was recorded regularly at 30 days interval. The yield and quality parameters were worked out during harvesting stage.

Statistical analysis

The experimental data was statistically analyzed using AgRes Software statistical package (Agres Statistical Software Version 3.01, Pascal International Software Solutions, USA) for getting best treatment.

RESULTS AND DISCUSSION

Growth parameters

Plant height

The recorded data from field investigation is presented in Figure 3; it is clear that plant height was decreased with increasing salinity levels. The maximum height (77.8 cm) was recorded in plots irrigated with fresh water (T_1) followed by salinity treatments T_2 and T_3, respectively. The highest salinity levels reduced the plant height significantly compared to fresh water treatment. The obtained results are in agreement with the findings reported by Malash et al. (2008). The highest tested salinity (T_3) reduced plant height (7.71%) compared to T_1 (fresh water) after 120 days after transplanting (DAT). Cetin and Demet (2008) reported that canopy cover of tomato crop increased and reached maximum (70-100%) value at the middle of crop growth period and afterwards it remain constant until end of growing season. On the other hand the obtained results showed that the different discharge rates significantly affected the plant height. The highest plant height was recorded in irrigation applied with discharge of Q_3 followed by Q_2 and Q_1.

Plant yield

Plant yield as affected by different salinity levels, irrigation levels and discharge rate of emitters is shown in Table 3. It was found that the plant yield decreased with the increase of salinity levels in irrigation water, that is, from T_1 to T_3 significantly. The maximum plant yield (3.91

Figure 2. View of the experimental field after removing plastic cover during day time.

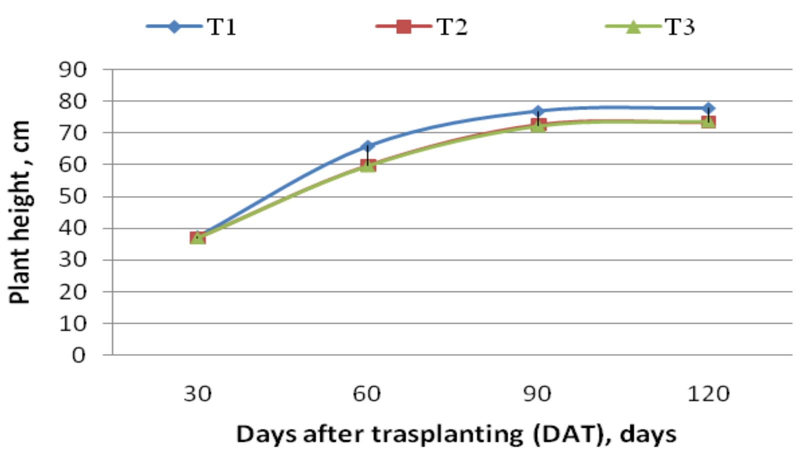

Figure 3. Variation in plant height at different salinity level.

kg/plant) was recorded in the treatment $I_3Q_2T_1$ followed by $I_3Q_1T_1$ while, the minimum plant yield (2.39 kg/plant) was recorded in the treatment $I_1Q_3T_3$. The irrigation levels I_2 and I_3 showed a significant increase in plant yield as compared to I_1. On the other hand, the increase in the discharge rate of emitters significantly decreased the plant yield. The average plant yield decreased by 11.51, and 25.84% in saline water treatment T_2 and T_3, respectively as compared to T_1 (fresh water). The interaction of irrigation levels and salinity treatment also showed a significant effect on plant yield. The tomato plants recorded the maximum yield under the discharge rate of Q_1 followed by Q_2 and Q_3 in each salinity treatment (T_1 to T_3). This finding has close proximity with Badr and Taalab (2007) who reported that the maximum yield obtained with surface drip irrigation applied at 2 lph and lowest yield obtained when water applied at 8 lph with surface drip irrigation in saline water. Yield reduction due to saline water caused mainly due to reduction in fruit weight which in turn is directly proportional to fruit size. This is in accordance with the findings of Reina-Sa´nchez et al. (2005) and Malash (2008) who reported that the plant yield decreased with increasing salinity probably due to reduction in fruit weight. The reduction in water

Table 3. Tomato yield under different irrigation levels, discharge rate and fresh and saline water ratio (salinity levels).

Treatment	I_1			I_2			I_3		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
T_1	3.32	3.27	3.09	3.80	3.55	3.52	3.82	3.91	3.76
T_2	3.10	3.00	2.76	3.54	3.32	3.32	3.33	3.28	2.72
T_3	2.93	2.85	2.39	2.80	2.55	2.47	2.67	2.64	2.47

LSD(0.01) T= 0.231, IxT = 0.401; SE T = 0.086, IxT = 0.149.

Table 4. Water use efficiency (WUE) of tomato under different irrigation levels, discharge rate and fresh and saline water ratio (salinity levels) on crop.

Treatment	I_1			I_2			I_3		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
T_1	1.53	1.56	1.55	1.28	1.20	1.15	0.98	0.89	0.86
T_2	1.44	1.44	1.27	1.09	1.14	1.00	0.83	0.82	0.88
T_3	1.36	1.37	1.23	0.93	0.88	0.89	0.72	0.71	0.66

LSD(0.01): T = 0.039, IxQxT = 0.119; SE: T = 0.0149, IxQxT = 0.044.

uptake when irrigated with saline water was also main cause of yield reduction. This finding has close proximity with Romero-Aranda et al. (2000) who reported that that tomato plants irrigated with a saline solution transpire less water than irrigated with fresh water.

The variation in yield with the different combination of treatments was probably due to the variation in presence of soluble salts. The increasing EC value for different treatments was due to the increase in Na^+ and Cl^- ions concentration. The increase in concentration of these ions might have developed more negative osmotic potential in soil solution and caused reduced water and nutrient uptake thereby growth and yield affected adversely. Grattan and Grieve (1999) observed that presence of Na^+ reduces K^+ uptake while Cl^- reduces NO_3^- uptake by the plant. Irshad et al. (2009) also reported maize leaf and root dry matter yield was reduced significantly by saline irrigation water.

Water use efficiency (WUE)

The water use efficiency under different salinity levels, discharge rates and irrigation levels are presented in Table 4. The data showed that the water use efficiency decreased with the increase in salinity levels of irrigation water. A significant difference was found between salinity treatments T_1, T_2 and T_3. The average maximum WUE (1.22 t/ha-cm) was found in T_1 followed by T_2 (1.10 t/ha-cm) and T_3 (0.97 t/ha-cm). The irrigation levels and discharge rate of emitters had a significant effect on WUE of tomato crop. The WUE decreased with increasing irrigation levels from I_1 to I_3. Also, the average WUE decreased with the increase in the discharge rate of emitters under given treatment combination. The interaction of IxT also showed the significant effect on WUE. The maximum and minimum WUE of 1.54 and 0.69 t/ha-cm was found in treatment combination of I_1T_1 and I_3T_3, respectively. The similar findings reported by Reina-Sa´nchez et al. (2005) that WUE reduced as salinity in nutrient solution increased. Romero-Aranda et al. (2002) also reported lower WUE in saline water than control condition.

Quality parameters of tomato

The effect of water salinity and discharge rate on the quality of tomato fruits such as Total soluble solids (TSS), acidity and ascorbic acid were studied and discussed under following heads.

Total soluble solids (TSS)

The data on the effect of irrigation levels, discharge rate of emitters and ratios of fresh and saline water on TSS of tomato fruits is shown in Table 5. The significant variation was found in TSS of tomato fruits with the treatments of T_1, T_2 and T_3. The reduced water uptake in plants irrigated by saline water led to increase in solute concentrations (particularly sugars) and hence increased TSS contents. TSS increased with increase in salinity of irrigation water, that is, T_1 to T_3 under all discharge rates and irrigation levels. The maximum TSS of 6.2 was found in I1Q1T3 treatment. The minimum TSS was found in tomato irrigated with 100% fresh water in all irrigation levels. Yureseven et al. (2005) showed that increase of

Table 5. TSS (°brix) of tomato fruits under different irrigation levels, discharge rate and fresh and saline water ratio (salinity levels).

Treatment	I_1			I_2			I_3		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
T_1	5.8	5.7	5.5	5.5	5.3	5.0	5.4	5.3	5.2
T_2	6.1	6.0	5.8	5.9	5.9	5.6	5.9	5.8	5.6
T_3	6.2	6.2	6.2	6.1	6.2	5.9	6.2	5.9	5.8

LSD(0.01): T = .443, Q = NS, I = NS; SE: T = 0.165.

Table 6. Acidity (percent) of tomato fruits under different irrigation levels, discharge rate and fresh and saline water ratio (salinity levels).

Treatment	I_1			I_2			I_3		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
T_1	0.695	0.674	0.651	0.684	0.668	0.658	0.715	0.683	0.689
T_2	0.708	0.710	0.668	0.733	0.698	0.687	0.742	0.723	0.705
T_3	0.735	0.727	0.697	0.755	0.752	0.720	0.758	0.738	0.726

LSD(0.05): T = 0.0393, Q = NS, I = NS; SE: T = 0.0196.

Table 7. Ascorbic acid (mg/100 g) of tomato fruits under different irrigation levels, discharge rate and fresh and saline water ratio (salinity levels).

Treatment	I_1			I_2			I_3		
	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
T_1	29.23	30.18	31.55	31.48	32.36	24.78	30.78	32.89	28.88
T_2	32.76	31.33	31.85	33.23	32.76	30.21	37.16	35.80	35.06
T_3	34.98	35.10	32.63	34.54	33.15	32.13	37.41	37.23	36.75

LSD(0.01): T = 4.169, Q = NS, I = NS; SE: T = 1.559.

TSS in tomato fruits with increasing salinity levels from 0.25 to 10 dS/m. Malash et al. (2005, 2008) also reported increasing TSS content of tomato fruits with increasing saline ratio of irrigation water. The average value of TSS was found maximum in Q_1 treatment followed by Q_2 and Q_3 treatments but the differences were statistically insignificant. In irrigation levels, average TSS was found maximum in I_1 followed by I_2 and I_3. This trend supports findings obtained by Hanson and May (2004) and Hanson et al. (2006) who reported that soluble solids increased with decreasing applied water.

Acidity

The data presented in Table 6 show that acidity of tomato fruits increased with the increase in saline water ratio. A significant difference was found in acidity of tomato among T_1, T_2 and T_3. However, no significant difference was in the acidity between T_1 and T_2 treatments. Among the irrigation levels and discharge rate of emitters, there was no significant difference was found in acidity of tomato fruits while the average acidity increased with the increase in irrigation levels and decreased with the increase in the discharge rate of emitters. The maximum acidity (0.758%) was recorded in $I_3Q_1T_3$ treatment and the minimum (0.651%) in $I_1Q_3T_1$ treatment. The similar trend was found by Magan et al. (2008) and Mitchell et al. (1991) who reported that the titrable acidity increased with increasing EC of the nutrient solution and tomato fruits grown under salt stress showed higher organic acid contents and titrable acidity than fruits grown with fresh water.

Ascorbic acid

The effect of salinity levels, irrigation levels and discharge rate of emitters on ascorbic acid of tomato fruits is presented in Table 7. The ascorbic acid increased significantly with the increasing in salinity levels of irrigated water. The results are in concurrence with Sandra et al. (2006) who reported that rising salinity levels in nutrient solution significantly increased Vitamin C, lycopene, β carotene in fresh fruits. The average value of ascorbic acid was minimum (24.78 mg/100 g) in treatment $I_3Q_3T_1$ and the maximum (37.41 mg/100 g) under $I_3Q_1T_3$ treatment. The significant difference was found between of the treatments T_1 and T_3. However, no significant difference was found between T_2 and T_3 treatments. It was observed that there was no significant difference in ascorbic acid was found between the tested discharge rate of emitters or irrigation levels. Although, it was observed that ascorbic acid was decreased with the increase in discharge rate of emitters non-significantly. The maximum ascorbic acid was found with discharge rate of Q_1 followed by Q_2 and Q_3.

Conclusions

It can be concluded from the present field investigation that the maximum yield can be obtained by applying fresh water with discharge rate of 1.2 lph at IW/CPE ratio of 0.8. The increase in salinity ratio increased the quality of tomato but reduced the yield. The mixing of 75% fresh and 25% saline water with EC up to 6.3 dS/m can be applied with discharge rate of 2.4 lph and IW/CPE ratio of 0.8 improve the quality of tomato with slightly reduction in fruit yield of 11% as compared to fresh water. So, keeping in mind the availability of both fresh and saline water, yield reduction and quality of tomato, the discharge rate and IW/CPE ratio was recommended.

REFERENCES

Badr MA, Taalab AS (2007). Effect of Drip Irrigation and Discharge Rate on Water and Solute Dynamics in Sandy Soil and Tomato Yield. Australia J. Basic Appl. Sci. 1(4):545-552.

Cetin O, Demet U (2008). The effect of drip line spacing, irrigation regime and planting geometries of tomato on yield, irrigation water use efficiency and net return. Agric Water Mangt. 95:949-958.

Dasberg S, Or D. (1999). Drip Irrigation. Springer-Verlag, Berlin, P. 162.

Grattan SR, Grieve CM (1999). Salinity-mineral nutrient relations in horticultural crops. Scientia Horticulturae 78:127-157.

Hanson BR, Hutmacher RB, May DM (2006) Drip irrigation of tomato and cotton under shallow saline ground water conditions. Irrig. Drain. Syst. 20:155-175.

Hanson B, May D (2004) Effect of subsurface drip irrigation on processing tomato yield, water table depth, soil salinity and profitability. Agric Water Mangt. 68:1-17.

Irshad MA, Eneji EA, Khattak RA, Khan A (2009). Influence of Nitrogen and SalineWater on the Growth and Partitioning of Mineral Content in Maize. J. Plant Nutr. 32:458-469,

Jain AK, Kumar R (2007). Water management issues – Punjab, North-West India. Indo-US Workshop on Innovative E-technologies for Distance Education and Extension/Outreach for Efficient Water Management, March 5-9, 2007, ICRISAT, Patancheru/Hyderabad, Andhra Pradesh, India

Magan JJ, Gallardo M, Thompson RB, Lorenzo P (2008). Effect of salinity on fruit yield and quality of tomato grown in soil-less culture in greenhouse in Mediterranean climate conditions. Agric Water Mangt. 95:1041-1055.

Malash N, Flowers TJ, Ragab R (2005). Effect of irrigation systems and water management practices using saline and non-saline water on tomato production Agric Water Mangt. 78:25-38.

Malash, NM, Flowers TJ, Ragab R (2008). Effect of irrigation methods, management and salinity of irrigation water on tomato yield, soil moisture and salinity distribution. Irrig. Sci. 26:313–323.

Meiri A, Plantz Z (1985). Crop production and management under saline conditions. Plant soil. 89:253-271.

Minhas PS (1996). Review-Saline water management for irrigation in India. Agric. Water. Mangt. 30:1-24.

Minhas PS, Bajwa MS (2001). Use and management of poor quality waters for the rice-wheat based production system. J. Crop Prod. 4:273–305.

Mitchell JP, Shenna C, Grattan SR, May DM (1991). Tomato fruit yield and quality under water deficit and salinity. J. Am. Soc. Horti. Sci. 116:215-221.

Oster JD, Jaiwardhane NS, (1998). Agricultural management of sodic soils. In: summer, M.E. Naidu, R. (Eds) sodic soils: Distribution, processes, management and environmental consequences oxford university. pp.125-147.

Pasternak D, De Malach Y. (1995). Crop irrigation with saline water. In: Pessarakli, M. (Ed.),Handbook of Plant and Crop Stress. Marcel Dekker, Inc., NY, pp. 599-622.

Reina-Sa´nchez A, Romero-Aranda R, Cuartero J (2005) Plant water uptake and water use efficiency of greenhouse tomato cultivars irrigated with saline water. Agric. Water Mangt. 78:54-66.

Rhodes JD, Kandiah A, Mashak AM. (1992). The use of saline waters for crop production. Irrigation and Drainage, FAO, Rome Italy, 48:150.

Romero-Aranda, R, Soria T, Cuartero J (2000) Tomato plant-water uptake and plant-water relationships under saline growth conditions. Plant Sci. 160:265-272.

Romero-Aranda, R, Soria T, Cuartero J, (2002) Greenhouse mist improves yield of tomato plants grown under saline conditions. J. Am. Soc. Hort. Sci. 127:644-648.

Sandra K, Wilfried H. Schnitzler, Johanna G, Markus W (2006). The influence of different electrical conductivity values in a Simplified re-circulating soilless system on inner and outer fruit quality characteristics of tomato. J. Agric. Food Chem. 54 (2):441–448.

Yureseven E, Kesmez G D,Unlukara A (2005) The effect of water salinity and potassium levels on yield, fruit quality and water consumption of native central anatolian tomato species (Lycopercicon esculantum). Agric. Water Mangt. 78:128-135.