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USE OF SALINE WATER FOR GREENHOUSE BELL PEPPER (*CAPSICUM ANNUUM*) PRODUCTION

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ABSTRACT

A greenhouse experiment was conducted to study the response of bell pepper to quality of irrigation water and irrigation regimes. The main treatments included non-saline water (EC-0.5 dS m^{-1}) and saline water (EC-3.5 dS m^{-1}). The sub-treatments included three irrigation regimes (at 100, 80 and 60% of crop Evapotranspiration (ET_c)) in combination with three crop growth stages (vegetative, flowering to fruit set and fruit development to harvest). Application of saline water significantly reduced marketable fresh fruit yield from 5.47 to 2.60 kg m^{-2}. Irrigation at 80% ET_c till the end of vegetative stage and at 100% ET_c later significantly increased the yield (5.01 kg m^{-2}). Irrigation with non-saline water at either 80 or 60% ET_c till the end of vegetative stage and at 100% ET_c later resulted in similar fresh fruit yield. Saline water irrigation at 80% ET_c till the end of vegetative stage and at 100% ET_c later, proved superior to all the other treatments. Use of saline water (3.5 dS m^{-1}) for irrigation of greenhouse bell pepper resulted in an increase in soil electrical conductivity and caused a drop in the fresh fruit yield by 72% as compared to irrigation with non-saline water (0.5 dS m^{-1}). Irrigation at 80% ET_c in the vegetative stage and at 100% ET_c in the other two stages (flowering to fruit set and fruit development to harvest) recorded significantly higher total (5.52 kg m^{-2}) and marketable (5.01 kg m^{-2}) fresh fruit yield than all the other irrigation treatments. Saline water irrigation improved fruit quality with higher TSS (10.80%), Vitamin C (228.66 mg^{-100g}) and acidity (0.305%).

Keywords: Water Quality, Water Use Efficiency, Normalized Difference Vegetation Index, Canopy Temperature, Saudi Arabia

1. INTRODUCTION

The ever increasing demand for fresh water resources is a global concern. However, it is a serious challenge in Saudi Arabia, which is striving hard to attain sustainability of agriculture and ensure food security. To meet the growing demand for food, the country relies mainly on finite water resources from deep aquifers. Agriculture consumes about 90% of total water consumption in the country. The agricultural crops such as wheat, alfalfa, Rhodes grass, potatoes, are grown under field conditions using center pivot irrigation systems. There is a growing fear that acute shortage of water may adversely affect agriculture. Thus, there is an urgent need to conserve natural resources and to increase the input use efficiencies to achieve agricultural sustainability in the Kingdom. Greenhouses offer an ideal alternative to traditional agriculture for meeting the urgent needs of the Kingdom; the carefully-controlled microclimates within greenhouses favour crop

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productivity, reduce transpiration and increase water-use efficiency by a factor of 3 to 5. The scarcity of water in most Mediterranean areas highlights the objective of optimizing its productivity, with adequate and efficient irrigation (Castilla, 1990). Protected cultivation improves water productivity due to reduction in the Evapotranspiration (ET) and increased production (Stanghellini, 1993). Soil and water salinity in the arid regions are continuously increasing (Rus *et al*., 2000). In recent times, greenhouse cultivation has assumed importance in view of its efficient use of land and water resources. Bell pepper is an important commercial greenhouse vegetable crop cultivated in Saudi Arabia. Due to scarcity of non-saline water, use of recycled waste water/desalinized water is often used in agriculture. However, there are serious limitations to the continuous use of poor quality water for agriculture especially for cultivation of crops in greenhouses. The continued use of saline water in greenhouse-grown crops results in build-up of soil salinity in the root zone that may be detrimental to growth and yield (Flowers, 1999; Sonneveld, 2000). There are very few reports on the effects of salts on greenhouse pepper (Sonneveld, 1979; Sonneveld and van der Burg, 1991; De Kreij, 1999). Although pepper plants have been reported to be moderately sensitive (Maas and Hoffman, 1977; Pasternak and Malach, 1994) to very sensitive to saline water (Sonneveld and van der Burg, 1991) but, greenhouse-grown bell pepper has been reported to be sensitive (Chartzoulakis and Klapaki, 2000; Navarro *et al*., 2002) or moderately sensitive to salinity (Ayers and Westcot, 1985; Rhoades *et al*., 1992) due to adverse effect of high salt concentration on stomatal conductance and net photosynthesis (Gunes *et al*., 1996; De Pascale *et al*., 2003; Lycoskoufis *et al*., 2005). Despite its varied sensitivity to salinity, bell pepper is often cultivated in greenhouses by using saline water. In Cyprus, Papadopoulos (1998) obtained a yield of 79 t ha^{-1} of green house grown bell peppers using saline water with an EC of 3.1 dS m^{-1}. However, Rubio *et al*. (2010) reported decreased above-ground total biomass and marketable fruit yield from the saline water treatment (4.6 dS m^{-1}) when compared to control (2.6 dS m^{-1}) and increased water use efficiency by reducing the frequency of per day irrigation from eight to one. In recent times, bell pepper is extensively cultivated in greenhouses in Saudi Arabia. Nevertheless, there are no reports of the effects of water quality and irrigation levels on the greenhouse bell pepper. Therefore, this study was carried out to investigate the effects of quality of irrigation water and levels of irrigation on fresh fruit yield and quality of greenhouse grown bell pepper.

2. MATERIALS AND METHODS

2.1. Experimental Details

The study was conducted in a controlled polyethylene greenhouse at the Dirab Research and Agricultural Experimental Station of King Saud University, Dirab, Saudi Arabia. The experiment was laid out in Strip Split Plot design with two water quality (main) treatments (Q1-non-saline water with an EC of 0.5 dS m^{-1} and Q2-saline water with an EC of 3.5 dS m^{-1}) and nine irrigation (sub) treatments. The irrigation treatments composed of irrigation at three levels of crop evapotranspiration (ET_c): 60, 80 and 100% ET_c, applied at three crop growth stages: First stage-vegetative (1 to 45 days from transplanting); second stage-flowering to fruit set (46 to 90 days) and third stage-fruit development to harvest (90 to 210 days). The following irrigation treatments were included: I_1-irrigation at 100% ET_c throughout the crop growth period; I_2-irrigation at 80% ET_c throughout the crop growth period; I_3-irrigation at 80% ET_c during the first stage + irrigation at 100% ET_c during the other two stages; I_4-irrigation at 80% ET_c during the second stage + irrigation at 100% ET_c during the other two stages; I_5-irrigation at 80% ET_c during the third stage + irrigation at 100% ET_c during the other two stages; I_6-irrigation at 60% ET_c throughout the crop growth period; I_7-irrigation at 60% ET_c during the first stage + irrigation at 100% ET_c during the other two stages; I_8-irrigation at 60% ET_c during the second stage + irrigation at 100% ET_c during the other two stages; and I_9-irrigation at 60% ET_c during the third stage + irrigation at 100% ET_c during the other two stages. The treatments were replicated three times.

Five-week old seedlings of bell pepper hybrid (cv. Taranto) were transplanted into a sandy soil (84% sand) on October 4, 2010, where the treatments were imposed starting November 1, 2010. The plant spacing adopted was 1×0.5 m. Irrigation water was supplied to each plant with a dripper emitting 4 litres of water/hour. The amount of irrigation water based on crop Evapotranspiration (ET_c) was calculated as per Allen *et al*. (1998). Fertilizer application and other cultural practices were conducted based on the recommendation of Maynard and Hochmuth (2013).

2.2. Observations on Soil and the Crop

Periodic soil EC, canopy temperature and Normalized Difference Vegetation Index (NDVI) readings were taken one hour after irrigation cycle ended. Soil EC measurements (dS m^{-1}) were made at a depth of 7.5 cm using Field Scout Soil EC meter (Spectrum Technologies, USA). Crop canopy temperature was recorded using Infrared Thermometer.

NDVI values were measured using NDVI meter (CM 1000 of Spectrum Technologies, USA). The total fresh fruit yield per plant of six harvests made at one week interval was recorded. Soil EC and crop yield data was statistically analyzed using SAS software program (SAS, 2002). Differences between treatment means were tested by using an L.S.D. test at 0.05 level.

2.3. Fruit Quality Analyses

Total Soluble Solids (TSS), total sugars, vitamin C as L-ascorbic acid and titrable acidity were determined according to the method described by AOAC (1995).

3. RESULTS

Quality of irrigation water and irrigation regime had significant influence on the growth and yield parameters, fresh fruit yield, fruit quality and water use efficiency of bell pepper.

3.1. Soil EC

The soil EC was significantly influenced by the quality of water. Saline water use resulted in significantly higher soil EC compared to non-saline water consistently throughout the crop growth period. The soil EC values varied from 1.157 to 1.661 dSm^{-1} in non-saline water treatment and from 1.632 to 2.808 dSm^{-1} in saline water treatment (**Fig. 1**). The differences in soil EC values between non-saline water and saline water were narrower during the initial stages and considerably widened during the later stages of crop growth. Irrigation regimes did not significantly affect soil EC levels except on three dates.

3.2. Normalized Difference Vegetation Index (NDVI)

The NDVI values were lower with the use of saline water than with non-saline water, throughout the crop growth period except on two dates (**Fig. 2**). Irrigation regimes did not have significant effect on NDVI except on three dates.

3.3. Crop Canopy Temperature

Crop canopy temperature throughout the crop growth period was significantly higher with the use of saline water than with the use of non-saline water (**Fig. 3**). The values varied between 21.99° and 32.12°C for non-saline water and from 23.95° and 36.02°C for saline water. There was no definite trend in the influence of irrigation regimes on crop canopy temperature.

3.4. Fruit Yield

Total and marketable fresh fruit yield of greenhouse-grown bell pepper was inversely proportional to the salinity of irrigation water. Quality of irrigation water significantly influenced the NDVI and both total and marketable fresh fruit yield. Non-saline water treatment resulted in significantly superior total and marketable fresh fruit yield as compared to saline water treatment (**Table 1 and Fig. 4**). Saline water use caused a greater reduction in the marketable fresh fruit yield (from 5.47 to 2.60 kg m^{-2}) than the total fresh fruit yield (from 5.54 to 3.66 kg m^{-2}).

Significant variation in the fresh fruit yield against irrigation regimes was also observed. Irrigation at 80% ET_c in the vegetative stage and at 100% ET_c in the other two stages (flowering to fruit set and fruit development to harvest) recorded significantly higher total (5.52 kg m^{-2}) and marketable (5.01 kg m^{-2}) fresh fruit yield than all the other irrigation treatments. The total fresh fruit yield obtained by irrigating the crop with non-saline water at either 80% ET_c in any of the three stages or at 60% ET_c in the first stage followed by irrigating at 100% ET_c in the remaining two stages was on par with the total fresh fruit yield of 6.02 kg m^{-2} obtained with irrigation at 100% ET_c throughout the cropping period.

3.5. Water Use Efficiency (WUE)

Significantly higher WUE of 8.558 kg m^{-3} was observed by irrigation of the crop with non-saline water than by saline water (5.690 kg m^3) (**Table 1**). Irrigation of the crop at 60 % ET_c during the entire cropping period resulted in significantly higher WUE (8.653 kg m^3) than all the other irrigation regimes. Irrigation with non-saline water at 60% ET_c during the entire cropping period was the best treatment in terms of WUE (10.344 kg m^3). This treatment combination was significantly superior to all the other treatment combinations except the one with non-saline water at 60% ET_c in the vegetative stage and at 100% ET_c in the remaining two stages.

3.6. Fruit Quality

Irrigation with saline water resulted in fresh fruits of superior quality parameters (total sugar-6.556%; TSS-10.80%; acidity-0.305% and vitamin C-228.66 mg^{-100g}) (**Table 2**). Irrigation at 100% ET_c during the entire cropping season resulted in significantly higher

TSS (11.02%) and acidity (0.329%) than the other irrigation treatments. However, the vitamin C content was higher (243.37 mg $100g^{-1}$) with irrigation at 80% ETc in the vegetative stage followed by 100% ET_c in the other two stages, than in the other treatments. Total sugar content (6.75%) was significantly higher with irrigation at 60% ET_c throughout the crop growth period, than in the other treatments.

Table 1. Effect of quality of water and irrigation regime on total and marketable fresh fruit yield of bell pepper and Water Use Efficiency (WUE)

	Total fresh fruit yield (kg/m^2)			Marketable fresh fruit yield (kg/m^2)			WUE (kg/m^3)		
Irrigation regime	Saline water	Non saline water	Mean	Saline water	Non saline water	Mean	Saline water	Non saline water	Mean
I1	3.86	6.02	4.94ab	2.55	6.01	4.28b	5.15	8.020	6.585cd
I2	3.11	4.93	4.02c	2.10	4.80	3.45c	5.18	8.220	6.701cd
I3	4.73	6.31	5.52a	3.76	6.25	5.01a	6.64	8.860	7.748ab
I4	3.74	5.99	4.86b	2.75	5.98	4.36b	5.25	8.410	6.832cd
I5	3.85	5.91	4.88b	2.71	5.87	4.29b	5.71	8.760	7.232bc
I6	3.13	4.65	3.89c	2.17	4.53	3.35c	6.96	10.340	8.653a
I7	3.64	6.29	4.96ab	2.63	6.21	4.42ab	5.39	9.320	7.352bc
I8	3.39	4.95	4.17c	2.38	4.91	3.64c	5.02	7.000	6.011d
I9	3.55	4.86	4.20c	2.39	4.70	3.54c	5.91	8.090	7.003bcd
Mean	3.66b	5.54c		2.60b	5.47a		5.690b	8.558a	

I_1-irrigation at 100% ET_c throughout the crop growth period; I_2-irrigation at 80% ET_c throughout the crop growth period; I_3-irrigation at 80% ET_c during the vegetative stage + irrigation at 100% ET_c during the other two stages; I_4-irrigation at 80% ET_c during the flowering to fruit set stage + irrigation at 100% ET_c during the other two stages; I_5-irrigation at 80% ET_c during the fruit development to harvest stage + irrigation at 100% ET_c during the other two stages; I_6-irrigation at 60% ET_c throughout the crop growth period; I_7-irrigation at 60% ET_c during the vegetative stage + irrigation at 100% ET_c during the other two stages; I_8-irrigation at 60% ET_c during the flowering to fruit set stage + irrigation at 100% ET_c during the other two stages and I_9-irrigation at 60% ET_c during the fruit development to harvest stage + irrigation at 100% ET_c during the other two stages

Table 2. Effect of quality of water and irrigation regime on bell pepper fruit quality

	TSS (%)			Acidity (%)			Vitamin C (mg/100 g)			Total sugars (%)		
Irrigation regime	Saline water	Non saline water	Mean	Saline water	Non Saline water	Mean	Saline water	Non Saline water	Mean	Saline water	Non Saline water	Mean
I1	12.43	9.60	11.02a	0.33	0.320	0.329a	251.14	211.74	231.44ab	5.89	6.13	6.01d
I2	10.60	9.33	9.97b	0.33	0.330	0.331a	230.68	202.65	216.66bc	6.23	5.86	6.04d
I3	10.70	9.60	10.15ab	0.30	0.320	0.310ab	236.37	211.74	224.05ab	6.34	6.13	6.23bc
I4	10.37	9.90	10.14ab	0.28	0.280	0.281c	233.72	194.32	214.02bc	6.37	5.82	6.10cd
I5	10.70	10.00	10.35ab	0.30	0.310	0.307abc	264.78	221.97	243.37a	7.11	5.80	6.45abc
I6	10.80	9.77	10.29ab	0.31	0.290	0.300bc	263.26	177.65	220.45bc	7.08	6.43	6.75a
I7	10.30	10.17	10.23ab	0.27	0.310	0.292bc	213.26	217.42	215.34bc	6.63	5.82	6.23bcd
I8	10.57	10.17	10.37ab	0.31	0.290	0.298bc	200.00	237.12	218.56bc	6.61	5.66	6.14cd
I9	10.77	10.10	10.44ab	0.31	0.260	0.283bc	164.77	231.44	198.10c	6.83	6.24	6.54ab
Mean	10.80a	9.85b		0.305a	0.302b		228.66a	211.78b		6.556a	5.987b	

I1-irrigation at 100% ETc throughout the crop growth period; I2-irrigation at 80% ETc throughout the crop growth period; I3-irrigation at 80% ETc during the vegetative stage + irrigation at 100% ETc during the other two stages; I4-irrigation at 80% Etc during the flowering to fruit set stage + irrigation at 100% ETc during the other two stages; I5-irrigation at 80% ETc during the fruit development to harvest stage + irrigation at 100% ETc during the other two stages; I6-irrigation at 60% ETc throughout the crop growth period; I7-irrigation at 60% ETc during the vegetative stage + irrigation at 100% ETc during the other two stages; I8-irrigation at 60% ETc during the flowering to fruit set stage + irrigation at 100% ETc during the other two stages and I9-irrigation at 60% ETc during the fruit development to harvest stage + irrigation at 100% ETc during the other two stages

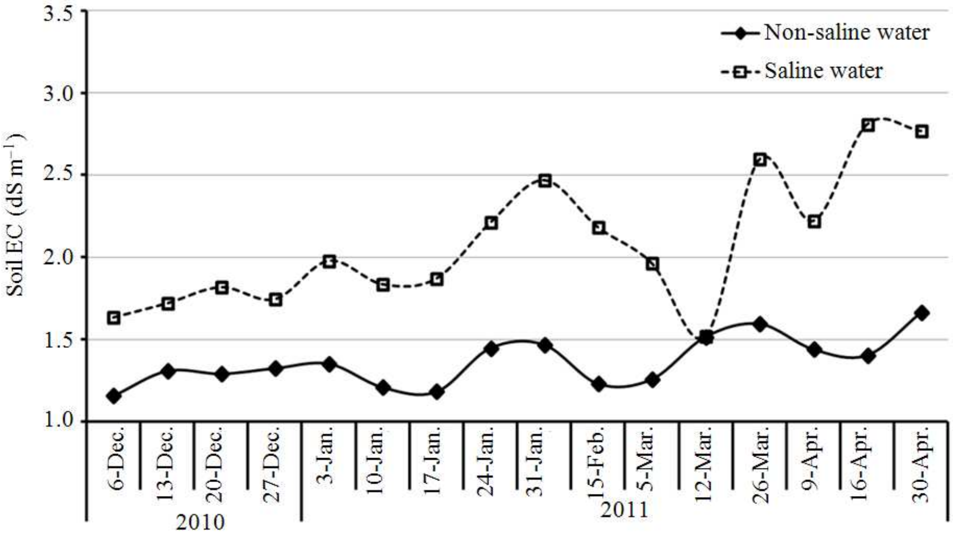

Fig. 1. Effects of water quality on temporal changes in soil electrical conductivity (dS m^{-1})

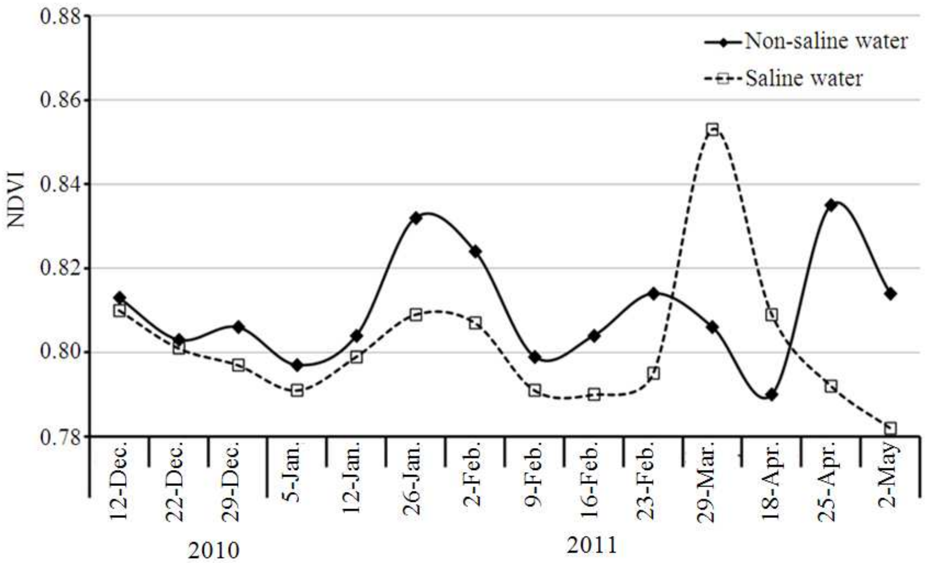

Fig. 2. Influence of quality of water on temporal changes in NDVI

4. DISCUSSION

4.1. Effect of Irrigation Water Quality on Bell Pepper Fruit Yield

Total and marketable fresh fruit yield of greenhouse-grown bell pepper was inversely proportional to the salinity of irrigation water. Quality of irrigation water significantly influenced the NDVI and both total and marketable fresh fruit yield. Non-saline water treatment resulted in significantly superior total and marketable fresh fruit yield as compared to saline water treatment (**Table 1**).

The total and marketable fresh fruit yield was drastically reduced by irrigation with of saline water. Saline water (3.5 dS m^{-1}) irrigation caused a drop in the fresh fruit yield by 72% as compared to irrigation with non-saline water (0.5 dS m^{-1}-**Fig. 1**).

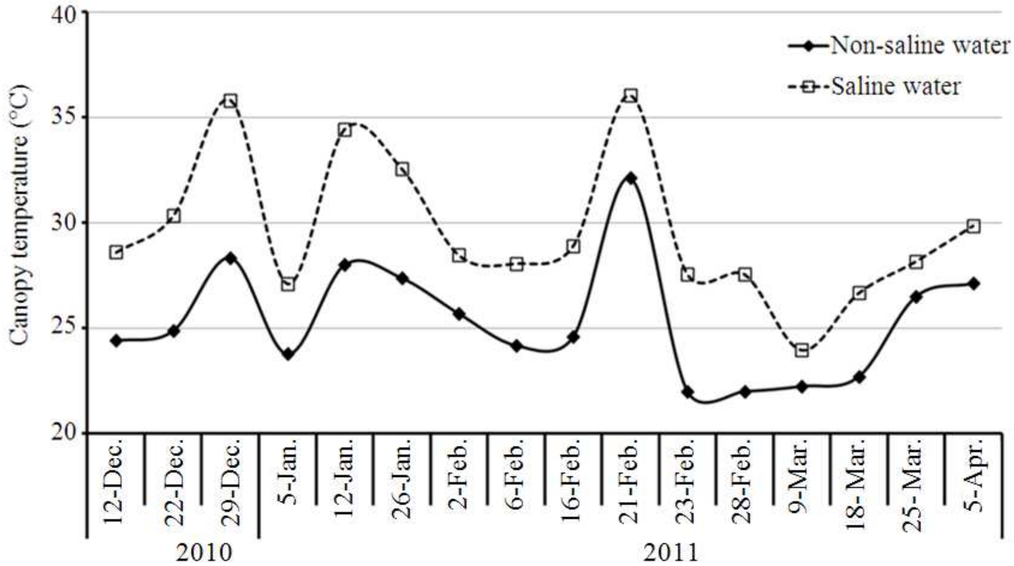

Fig. 3. Influence of quality of water on canopy temperature (°C)

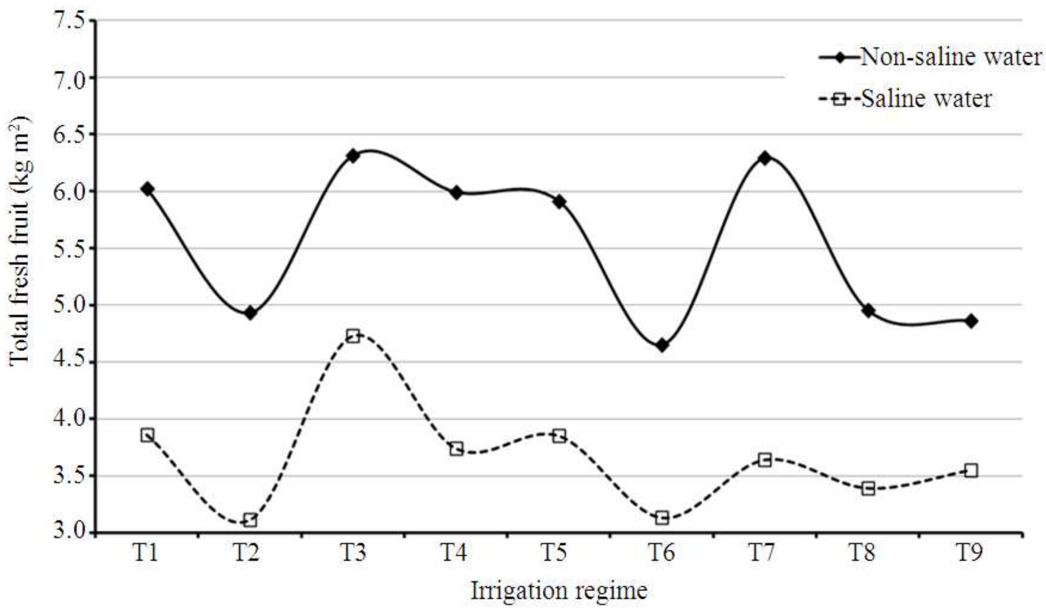

Fig. 4. Influence of quality of water on total fresh fruit yield (Kg m^2)

The results are in agreement with those of Chartzoulakis and Klapaki (2000) and Savvas *et al*. (2007) who obtained lower total and Class I fruit yield by irrigation with water of high salinity for greenhouse-grown bell pepper. Saline water use caused a greater reduction in the marketable fresh fruit yield (from 5.47 to 2.60 kg m^{-2}) than the total fresh fruit yield (from 5.54 to 3.66 kg m^{-2}). Similar results were reported by Rubio *et al*. (2010; 2011) who recorded lower marketable fruit yield from the saline water treatment (4.6 dS m^{-1}) when compared to control (2.6 dS m^{-1}). The lower fruit yield obtained by using saline water was mainly due to build up of soil salinity, since water quality exhibited an overriding effect on soil Electrical Conductivity (EC). Saline water use resulted in significantly higher soil EC compared to non-saline water consistently throughout the crop growth period. There was a steady increase in soil EC throughout the crop growth period in saline water treatment (**Fig. 1**) and are well above the threshold value of 1.5 dS m^{-1} (Maas and Hoffman, 1977; Chartzoulakis and Klapaki, 2000) and 1.8 dS m^{-1} (Maas, 1986) reported earlier. The increase in soil salinity in the root zone beyond the tolerance capacity of the crop might have resulted in substantial reduction in the yield of fruits. Lower yield in saline water treatment could also be due to significantly higher crop canopy temperatures (**Fig. 3**) and lower NDVI values (**Fig. 2**). Higher NDVI values represent higher biomass production and a healthy crop. De Pascale *et al*. (2003) attributed lower pepper yield at higher salinity level to reduced vegetative growth associated with marked inhibition of photosynthesis (Nieman *et al*., 1988; Bethke and Drew, 1992; Chartzoulakis and Klapaki, 2000) and decreased biomass production (Ben-Gal *et al*., 2008). Reduced growth and yield of bell pepper due to salinity was attributed to reduced water content in leaves caused by poor osmotic adjustment (Navarro *et al*., 2002), osmotic effect and increased Na^+ and Cl^- in the leaves (Lycoskoufis *et al*., 2005) and decreased transpiration (Ben-Gal *et al*., 2008).

Saline water use resulted in 34% lower total fresh fruit yield and 52% lower marketable fresh fruit yield as compared to non-saline water use. This differential response was indicative of the effect of saline water not just on the total fruit yield but also on the marketability of fruits. Blossom End Rot (BER) disease was observed in saline water treatments that caused lower marketable fresh fruit yield. Similar observations were made by Rubio *et al*. (2009) who recorded lower fruit weight and higher number of fruits affected by BER due to salinity. The marketable fresh fruit yield with the use of saline water was 71% of the total fresh fruit yield, while it was 99% when non-saline water was used. The results obtained in this study are in close agreement with the report of Rubio *et al*. (2011), who obtained marketable fruit yield of about 85% from the total fruit yield under non-saline conditions, whereas under saline conditions, it was between 55 and 76%. Also, previously, the reduction in marketable yield in pepper plants was mainly attributed to BER disease incidence (Silber *et al*., 2005) caused by increased salinity in the root medium (Rubio *et al*., 2009). Although the mechanisms leading to BER disease incidence under saline conditions in pepper are not clear, generation of oxygen free radicals in the apoplast (Aktas *et al*., 2005; Turhan *et al*., 2006) and poor Ca^{2+} status during rapid fruit expansion (Rubio *et al*., 2011) were suggested to be the contributing factors.

4.2. Effect of Irrigation Regime on Bell Pepper Fruit Yield

Four deficit irrigation regimes with non-saline water were significantly superior to all the other irrigation regimes, irrespective of the water quality. Similar trend was also observed in the marketable fresh fruit yield.

Higher total and marketable fresh fruit yield observed by irrigation at 80% ET_c in the vegetative stage followed by irrigation at 100% ET_c in the latter two stages was probably because the quantity of water supplied at 80% ET_c in the vegetative was enough to meet the water requirement of the crop in the early stage. However, during flowering to fruit set and fruit development to harvest, irrigation at 100% ET_c was probably necessary to meet the crop water requirement. This finding is supported by the work of Katerji *et al*. (1993) who reported that pepper plants are most sensitive to water stress during flowering and fruit development. The water deficit during the period between flowering and fruit development reduced final fruit production (Jaimez *et al*., 2000; Fernandez *et al*., 2005; Dorji *et al*., 2005). The deficit irrigation during the vegetative stage did not have advers effect on fruit yield in this study that gains support from a glasshouse study on ‘Sonar’ sweet pepper (*Capsicum annum* L.) by Chartzoulakis and Drosos (1997) who reported increased fruit dry mass by deficit irrigation.

4.3. Effect of Irrigation Water Quality and Irrigation Regime on Bell Pepper Fruit Quality

Irrigation with saline water resulted in fresh fruits of superior quality parameters (total sugar-6.556%; TSS-10.80%; acidity-0.305%; and vitamin C-228.66 mg $^{-100g}$-**Table 2**). Irrigation at 100% ET_c during the entire cropping season resulted in significantly higher TSS (11.02%) and acidity (0.329%) than the other irrigation treatments. However, the vitamin C content was higher (243.37 mg^{-100g}) with irrigation at 80% ET_c in the vegetative stage followed by 100% ET_c in the other two stages, than in the other treatments. Total sugar content (6.75%) was significantly higher with irrigation at 60% ET_c throughout the crop growth period, than in the other treatments. Improvement in the quality of fruits in terms of higher total sugars, TSS and Vitamin C by irrigation at 60% ET_c during the entire cropping season was probably due to reduced fruit water content and greater hydrolysis of starch in to sugars as reported by Kramer (1983). Ascorbic acid, an important source of Vitamin C, has been shown to have strong positive correlation ($r^2 > 90\%$) with changes in dry mass and TSS in sweet pepper fruit (Niklis *et al*., 2002). Dorji *et al*. (2005) also reported an improvement in bell pepper fruit quality by adopting deficit irrigation in a glasshouse study in New Zealand.

4.4. Effect of Irrigation Water Quality and Irrigation Regime on Water Use Efficiency (WUE)

Significantly higher WUE of 8.558 kg m^3 was observed by irrigation of the crop with non-saline water than by saline water (5.690 kg m^3-**Table 1**). Higher WUE observed by irrigation using non-saline water was mainly due to higher fruit yield. Irrigation of the crop at 60% ET_c during the entire cropping period resulted in significantly higher WUE (8.653 kg m^3) than all the other irrigation regimes. This was mainly due to lower quantity of water used and not due to increased fruit yield. However, the highest WUE (10.344 kg m^3) observed with non-saline water irrigation at 60% ET_c during the entire cropping period was due to increased yield as well as lower quantity of water used. This treatment combination was significantly superior to all the other treatment combinations except the one with non-saline water at 60% ET_c in the vegetative stage and at 100% ET_c in the remaining two stages.

The WUE values of 5.021 to 10.344 kg m^3 on fresh weight basis observed in this study were higher than the WUE limits of 2.7 and 5.0 g^{-1}, on dry weight basis, reported by Del Amor and Gomez-Lopez (2009). Total and marketable fresh fruit yield of greenhouse-grown bell pepper was inversely proportional to the salinity of irrigation water. The use of saline water (3.5 dS m^{-1}) for irrigation caused a drop in the fresh fruit yield by 72% as compared to the use of non-saline water (0.5 dS m^{-1}). Irrigation at 80% ET_c in the vegetative stage followed by irrigation at 100% ET_c in the other two stages (flowering to fruit set and fruit development to harvest) recorded significantly higher total (5.52 kg m^{-2}) and marketable (5.01 kg m^{-2}) fresh fruit yield than all the other irrigation treatments. Irrigation with saline water resulted in fresh fruits of superior quality parameters (total sugar-6.556%; TSS-10.80%; acidity-0.305%; and vitamin C-228.66 mg^{-100g}).

5. CONCLUSION

Use of saline water (3.5 dS m^{-1}) for irrigation of greenhouse bell pepper resulted in an increase in soil electrical conductivity and caused a drop in the fresh fruit yield by 72% as compared to irrigation with non-saline water (0.5 dS m^{-1}). However, irrigation with saline water resulted in fresh fruits of superior quality parameters (total sugar- 6.556%; TSS-10.80%; acidity-0.305% and vitamin C-228.66 mg^{-100g}). Irrigation at 80% ET_c in the vegetative stage and at 100% ET_c in the other two stages (flowering to fruit set and fruit development to harvest) recorded significantly higher total (5.52 kg m^{-2}) and marketable (5.01 kg m^{-2}) fresh fruit yield than all the other irrigation treatments.

6. ACKNOWLEDGEMENT

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