Effects of quality of water and irrigation regimes on temporal changes in soil EC and yield of greenhouse-grown bell pepper (*Capsicum annuum* L.)

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Abstract

A greenhouse experiment was conducted in Strip Split Plot design with three replications to study the response of bell pepper (cv. Taranto) to quality of irrigation water and irrigation regimes. The main treatments included good quality water (EC-0.6 dSm^{-1}) and saline water (EC-3.8 dSm^{-1}). The sub-treatments, however, included three irrigation regimes (at 100, 80 and 60 percent of crop evapotranspiration(ETc)) combined with three crop growth stages (vegetative, flowering to fruit setting and harvest). As expected, the application of saline water led to a significant increase in soil EC (up to 2.468 dSm-1) causing a drop in fresh fruit yield (from 1450.5 to 1038.8 g/plant for good quality and saline water, respectively). On the other hand, the irrigation regimes were not found to affect the soil EC, but noted to greatly affect the fresh fruit yield. The highest fresh fruit yield was obtained when irrigated at 100% ETc throughout the crop growth period. Combined effects of water quality and irrigation regimes on fresh fruit yield were found to be significant.

Keywords: bell pepper, green house, salinity, irrigation regimes

Introduction

Bell pepper is an important commercial greenhouse vegetable crop cultivated in Saudi Arabia.
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). Greenhouse-grown bell pepper has been reported to be sensitive (Chartzoulakis & Klapaki, 2000; Navarro et al, 2002) or moderately sensitive to salinity (Ayers & 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; Lycoskonfis et al, 2005).
Therefore, this study was designed and undertaken to investigate the effect of irrigation water quality and irrigation regime on temporal changes in soil EC. The consequent effects of these parameters on the yield of green house-grown bell pepper were also explored.

Materials and methods

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 treatments laid out in Strip Split Plot design comprised of the combination of two water quality treatments (Q1 for a good quality water with an EC of 0.5 dSm^{-1} and Q2 for a saline water with an EC of 3.5 dSm^{-1}) and nine irrigation treatments. The irrigation treatments were composed of irrigation at three levels of evapotranspiration (ETc), namely 60%, 80% and 100% applied at three crop growth stages. The first stage was the vegetative (1 to 45 days), the second was the flowering to fruit setting stage (46 to 90 days from transplanting) and the third was the harvesting stage (90 to 210 days from transplanting). Irrigation treatments were: I_1 - Irrigation at 100 ETc throughout the crop growth period; I_2 - Irrigation at 80% ETc throughout the crop growth period; I_3 - Irrigation at 80% ETc during the first stage + Irrigation at 100% ETc during the other two stages; I_4 - Irrigation at 80% ETc during the second stage + Irrigation at 100% ETc during the other two stages; I_5 - Irrigation at 80% ETc during the third stage + Irrigation at 100% ETc during the other two stages; I_6 - Irrigation at 60% ETc throughout the crop growth period; I_7 - Irrigation at 60% ETc during the first stage + Irrigation at 100% ETc during the other two stages; I_8 - Irrigation at 60% ETc during the second stage + Irrigation at 100% ETc during the other two stages; and I_9 - Irrigation at 60% ETc during the third stage + Irrigation at 100% ETc 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 adopted plant spacing was 1 X 0.5 m. Irrigation water was supplied to each plant with a dripper emitting 4 litres of water hour^{-1}. The amount of irrigation water based on crop evapotranspiration (ETc) was calculated as per Allen et al. (1998). Fertilizer application and other cultural practices were conducted based on the recommendation of Maynard and Hochmuth, (2007). Periodic soil EC measurements (dSm^{-1}) were made at a depth of 7.5 cm using Field Scout Soil EC meter (Spectrum Technologies, USA). The total fresh fruit yield per plant of six harvests made at one week intervals was recorded. Soil EC and crop yield data were statistically analyzed using SAS software program (SAS Institute, Cary, NC). Differences between treatment means were tested by using an L.S.D. test at 0.05 level.

Results

Effects of quality of water: The soil Electrical Conductivity (EC) values varied between 1.157 to 1.467 dSm^{-1} in good quality water treatment and between 1.632 to 2.468 dSm^{-1} in saline water treatment (Table 1).

Table 1. Soil EC (dSm^{-1}) as influenced by quality of water and irrigation regimes.

Treat-ment	6/12/2010	13/1/2010	20/1/2010	27/1/2010	3/1/2011	10/1/2011	17/1/2011	24/1/2011	31/1/2011	15/2/2011	5/3/2011
Q_1	1.157	1.308	1.291	1.324	1.352	1.209	1.182	1.446	1.467	1.231	1.258
Q_2	1.632	1.718	1.816	1.743	1.977	1.834	1.869	2.209	2.468	2.181	1.962
Mean	1.394	1.513	1.553	1.534	1.665	1.522	1.526	1.823	1.968	1.706	1.610
SE	0.014	0.029	0.034	0.036	0.018	0.011	0.004	0.117	0.090	0.064	0.034
LSD	0.060	0.126	0.146	0.156	0.074	0.047	0.017	0.118	0.387	0.275	0.147
I_1	1.381	1.517	1.644	1.368	1.684	1.529	1.548	1.844	2.434	1.702	1.721
I_2	1.373	1.531	1.586	1.541	1.688	1.481	1.536	1.894	1.972	1.681	1.666
I_3	1.368	1.489	1.571	1.540	1.68	1.501	1.532	1.784	1.923	1.730	1.565
I_4	1.459	1.483	1.52	1.322	1.681	1.490	1.518	1.799	2.017	1.776	1.595
I_5	1.426	1.502	1.563	1.613	1.679	1.511	1.527	1.815	1.975	1.841	1.628
I_6	1.406	1.487	1.563	1.585	1.639	1.525	1.523	1.846	1.883	1.661	1.606
I_7	1.382	1.531	1.532	1.610	1.613	1.552	1.510	1.857	1.854	1.614	1.610
I_8	1.362	1.558	1.484	1.624	1.651	1.535	1.501	1.778	1.826	1.666	1.583
I_9	1.407	1.522	1.521	1.599	1.664	1.550	1.536	1.848	1.828	1.681	1.517
Mean	1.396	1.513	1.554	1.534	1.664	1.519	1.526	1.829	1.968	1.706	1.610
SE	0.017	0.053	0.038	0.102	0.045	0.019	0.033	0.046	0.126	0.081	0.069
LSD	-	-	0.077	-	-	-	-	-	0.256	-	-

The soil EC was significantly influenced by the quality of water. Obviously, use of saline water resulted in a significantly higher soil EC as compared to pure water. There was a gradual increase in the soil EC during the first two months and decreased thereafter. The total fresh fruit

yield was reduced significantly from 1450.5 g per plant with good quality water to 1038.8 g per plant with saline water (Table 2).
Effects of irrigation regime: Irrigation regime did not significantly influence the root zone soil EC, except on two dates (December 13, 2010 and January 31, 2011). However, the irrigation regime exhibited a significant influence on the fresh fruit yield. Irrigation at 100% ETc throughout the crop growth period resulted in the highest fresh fruit yield of 1785.5 g plant^{-1}, which was significantly higher than with all other irrigation regimes (Table 2).
Interaction Effects: The interaction effects on soil EC were not significant. However, fresh fruit yield was significantly influenced (Table 2).

Table 2. Fresh fruit yield of bell pepper (g plant^{-1}) as influenced by quality of water and irrigation regime.

Irrigation regime	Saline water	Good quality water	Mean
I_1	1701	1870	1785.5
I_2	851	1419	1135
I_3	1535	1687	1611
I_4	1568	1782	1675
I_5	1306	1633	1469.5
I_6	455	990	722.5
I_7	606	1064	835
I_8	906	1563	1234.5
I_9	421	1047	734
Mean	1038.8	1450.5	1244.67

For comparing means of main treatments: SE = 1.398 & LSD = 6.016
For Comparing means of sub treatments: SE = 1.371 & LSD = 2.793
For comparing two sub treatments at the same level of main treatment:
SE = 2.301 & LSD = 4.6869
For comparing two main treatments at the same or different level of sub treatment:
SE = 4.882 & LSD = 9.9442

For all irrigation regimes included in the study, the good quality water treatment resulted in significantly superior fresh fruit yield as compared to saline water treatment. For saline and pure water treatments, irrigating at 100% ETc throughout the crop growth period was found to produce the highest yield of 1870 g plant^{-1}.

Discussion

The quality of water exhibited an overriding effect on soil EC (salinity) and performance of bell pepper. There was a gradual increase in soil EC throughout the crop growth period in saline water treatment. That increase was obviously due to a build up of salt salinity in the root zone due to continuous supply of saline water. The increased soil salinity had an adverse effect on the performance of bell pepper, where the fresh fruit yield was drastically reduced due to supply of saline water. Savvas et al., (2007) observed a similar suppression of total and Class I fruit yields due to salt accumulation in the root zone when water of high salinity was supplied to greenhouse-grown bell pepper. Irrigation water salinity was found to decrease the transpiration and the biomass production in bell pepper (Ben-Gal et al, 2008). Irrespective of the quality of water, irrigation at 100 % ETc throughout crop growth period was found to be superior to all other irrigation regimes, as evidenced by data on fresh fruit yield. Ben-Gal et al, (2008) reported that potential economic benefits from increased yields of bell pepper in green houses exist for saline water irrigation application rates reaching more than 200 % of the potential ET.

Conclusions

Fresh fruit yield of greenhouse-grown bell pepper was found to be inversely proportional to irrigation water salinity. The yield was decreased by 72% when saline water was used for irrigation as compared to irrigation with good quality water. For saline and good quality irrigation water, the highest fresh fruit yield was achieved when irrigation water was supplied at 100% ETc throughout the crop growth period.

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