The effect of municipal effluent with different irrigation systems on soil salinity and sodicity in an arid region

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Introduction

The required quality of effluent will depend on crops, soil conditions and the irrigation systems (Pereira et al., 2002). Reuse criteria can be relaxed some what using SD and SSD irrigation methods, because the soil acts as a complementary biofilter and there is no contact between the effluent and workers or the plant parts above the soil (Oron et al., 1999). Heidarpour et al. (2005) investigated the effect of municipal effluent using two irrigation methods and reported that the most important concern was the increase of EC in top soil layer with SSD irrigation. Hassanli and Javan (2005) observed thatthe use of municipal effluent with drip systems would not have a serious impact on environment but soil salinity is a major concern. Patterson (1999) reported that effluent irrigation generally adds significant quantities of salt to the soil environment unless leaching by rainfall, clean water or excess irrigation occurs. The objective of this study was to evaluate the effect of municipal effluent bydifferent irrigation methods on salinity and alkalinity within the root zone.

Materials and methods

Three irrigation methods SSD, SD and FI for effluent and fresh water were installed in a replicatedplot experiment at a sewage treatment site (Southern Iran) in an arid region with mean annual precipitation of 340 mm and evaporation of 2585 mm in 2004. The irrigation scheduling was based on the monitoring of soil moisture deficit at the root depth. In each irrigation event. The soil moisture depletion within the root zone was replenished. The selected chemical composition of irrigation water and the selected properties of the soil prior the experiment are given in Tables 1, 2. The SSD laterals each for a crop row were buried at a depth of 15 cm with dripping points of 30 cm apart and the SD laterals were laid on the soil surface beside the crop rows with the same dripping apart. The composite soil samples were collected for depths 0-20, 20-40, and 40-60 cm prior to experiment. At the end of each growing season the soil samples from each replication plot (18 plots) from the above depths were also collected. Soil EC and pH were measured by a conductivity meter and a pH meter from saturated past and Na+ by the flame photo meter. All analyses were performed using SAS statistical analysis. Separation of means was performed using multiple range test Duncan at $p<0.05$.

Table 1 Salinity and alkalinity of FW and EF Table 2. Some selected properties of soil before the expe

Soil depth cm	Texture	BD g/m^3	EC dS/m	pH	SAR	Na^+ meq/L
0-20	CL	1.26	0.703	8.3	0.51	0.98
20-40	CL	1.26	1.09	8.3	0.72	1.6
40-60	CL	1.53	1.29	8.3	2.12	3.9

Irrigation water	EC dSm^{-1}	pH	SAR
Effluent	1.47	7.9	4.36
Fresh water	0.49	7.75	0.79

Results and discussion

Total amount of irrigation water applied for sugar beet was 842, 875 and 1171 mm per ha in SSD, SD and FI irrigation systems, respectively. The effects of experimental treatments on EC, Ph, SAR and Na+ are given in Tables 3 and 4. There was an increase of salinity in surface layer (0-20 cm) in all irrigation methods. This increase was significant with SSD and

SD comparing to FI. The SSD pipes were placed at depth of 15 cm and there was an upward movement of water by evaporation and capillary rise, which resulted in the salt accumulation at the soil surface. Such process of behavior was also observed with SD, since water was released very slowly on the soil surface which let to salt build up in top soil layer. This result was expected and agrees with those reported by Choi and Suarez Rey (2004) and Heidarpour et al. (2005). The salinity in the layers 20-40 and 40-60 cm was reduced in plots irrigated with FI, whereas was increased in plots irrigated with SSD and SD. The salinity in the top layer was increased significantly ($p<0.05$) with both effluent and fresh water while in lower layers it decreased significantly in plots irrigated with fresh water. Effluent had caused an increase in pH in all soil depths whereas such trend was not observed with fresh water. However, the effect of irrigation methods on pH was not statistically significant. The SAR was significantly increased with effluent and decreased in plots supplied with fresh water. The SAR changed from 0.51, 0.72, and 2.12 in depths of 0-20, 20-40, 40-60 cm to 3.62, 3.48 and 4.72 (Tables 2, 3). This increase is expected, since the concentration of Na+ in effluent was much higher than that in the fresh water. Although SAR lowers than 15 are not much harmful, increasing in the long term as a result of effluent application could be a great concern.

A significant increase in Na^+ from 0.98, 1.6 and 3.9 to 7.5, 6.3 and 8.11 $meqL^{-1}$ in plots supplied with effluent was observed. While a considerable decrease in lower layers was observed in plots irrigated with fresh water. This is related to the high concentration of Na+ in the effluent comparing to the fresh water. Analyses of variance showed that there was a significant difference among the effect of irrigation methods on concentration of Na^+. This could be probably related to the different forms of water movement in the soil and different leaching rate of Na+ from top soil in different irrigation methods. The most important concern was an increase in EC and SAR in the top soil layer with SSD and SD irrigation methods which might have a negative impact on plant growth.

Table 3 The effect of different irrigation systems on soil salinity and alkalinity

Irrigation methods	EC (dS/m)	pH	SAR	Na^+ meq/L
0-20 cm				
Furrow	1.01 (b)*	8.59 (a)	2.82 (a)	4.75 (b)
Subsurface drip	2.03 (a)	8.38 (b)	2.38 (a)	5.93 (a)
Surface drip	2.20 (a)	8.27 (b)	1.04 (b)	3.06 (c)
20-40 cm				
Furrow	0.90 (b)	8.58 (a)	2.15 (ab)	3.26 (b)
Subsurface drip	1.30 (a)	8.44 (ab)	2.25 (a)	4.64 (a)
Surface drip	1.16 (ab)	8.37 (b)	1.44 (b)	2.86 (b)
40-60 cm				
Furrow	1.01 (a)	8.87 (a)	3.68 (a)	4.51 (ab)
Subsurface drip	1.41 (a)	8.37 (b)	2.22 (b)	5.18 (a)
Surface drip	1.33 (a)	8.31 (b)	1.82 (b)	3.92 (b)

Table 4 The effect of water quality on soil salinity and alkalinity

Water quality	EC (dS/m)	pH	SAR	Na^+ meq/L
0-20 (cm)				
Effluent	1.89 (a)*	8.58 (a)	3.62 (a)	7.5 (a)
Fresh water	1.60 (a)	8.25 (b)	0.54 (b)	1.64 (b)
20-40 (cm)				
Effluent	1.33 (a)	8.57 (a)	3.48 (a)	6.30 (a)
Fresh water	0.91 (b)	8.35 (b)	0.41 (b)	0.85 (b)
40-60 (cm)				
Effluent	1.62 (a)	8.67 (a)	4.72 (a)	8.11 (a)
Fresh water	0.88 (b)	8.36 (b)	0.44 (b)	0.97(b)

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