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Effect of irrigation with wastewater on root yield and yield components of sugar beet

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Key words: Root, Sugar beet, Wastewater, Yield components.

Abstract

In recent years, water deficit and environmental hazards of wastewater have promoted the development of wastewater reuse in irrigation of agricultural lands in many arid and semi-arid regions. An experiment was conducted out at the experimental farm of a leaven factory, where the effect of treated wastewater on yield and yield components of beet (*Beta vulgaris* L.) was studied during the growing season of 2013. Three, irrigation levels (I1: irrigation with wastewater once in whole experimental period, I2: irrigation with wastewater twice in whole experimental period and I3: irrigation with wastewater in whole experimental period) and six wastewater percentage levels (C1: 15% wastewater, C2: 30% wastewater, C3: 45% wastewater, C4: 60% wastewater, A: pure water and P: pure wastewater) were studied in a randomized complete block factorial design with three replications. Results illustrated that number of irrigations with wastewater did not have significant effect on root diameter, whereas it had significant effect on root length, sugar percentage, sugar yield and root yield. Also results showed that wastewater percentage did not have significant effect on root diameter but it had significant effect on root length, sugar percentage, sugar yield and root yield. The maximum increase of root yield was observed in irrigation with wastewater whole over growing season and plants which irrigated with 15% wastewater. Results also illustrated that irrigation with wastewater whole over the growth period had the most significant effect on yield components.

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Introduction

The demand for water is continuously increasing in arid and semi-arid countries. Therefore, water of higher quality is preserved for domestic use while that of lower quality is recommended for irrigation. Municipal wastewater is less expensive and considered an attractive source for irrigation in these countries (Al-Rashed and Sherif, 2000). Yaryan (2000) studied the effects of irrigation with treated wastewater, well water and irrigation systems on the yield of sugar beet, corn and sunflower and properties of soil. Who obtained that the yield of sunflower and corn was higher under wastewater treatment, compared to well water treatment. However, the differences were not statistically significant. Wastewater treatment increased pH, available N, P, K, Mn, Pb, Ni and Co, but EC_e was decreased significantly.

Wastewater and agriculture are two sectors where the economic and environmental benefits of joint water management have been demonstrated through case studies around the world. It has been shown that the nutrients embodied in wastewater can increase yield as much or more than a combination of tap water and chemical fertilizer (Lopez *et al.*, 2006; WHO, 2006; Kiziloglu *et al.*, 2007).

Erfani *et al.* (2001) showed that utilization of treated municipal wastewater has caused an increase in forage yield and whole plant dry matters as compared to irrigation with the well water. Tavassoli *et al.* (2010) to evaluate the effects of municipal wastewater with manure and chemical fertilizer on yield and quality characteristics of corn forage reported that irrigation with wastewater will increase forage yield. The reliable access to wastewater irrigation can improve farm productivity in water-constrained systems (Bradford *et al.*, 2003; Huibers and Van Lier, 2005).

Esmailiyan *et al.* (2008) reported that wastewater had positive significantly influence on grain yield and all yield components. Esmailiyan *et al.* (2011) showed that irrigation with wastewater significantly increase oil and protein percentage of the grains than well water. They also reported that wastewater irrigation due to higher chlorophyll content, proline and carbohydrate contents in green leaf tissues.

As Iran located in a semi arid region, providing new resources of irrigation is very important. Therefore the objective of this study was assessing the impacts of irrigation with wastewater on yield and yield components of sugar beet.

Materials and methods

This study was conducted at the experimental farm where is located at Tabriz (38° 18′ N, 45° 7′ E) during 2013 growing season. The climate is semi-arid and temperatures reaching up to 38°C in the months of May and June, Average temperature ranging between 18°C to 28°C. The mean annual rainfall is about 385mm. Experiment was carried out as a factorial based on complete block design with three replications. The treatments were three levels of number of irrigation (I_1: irrigation with wastewater once in whole experimental period, I_2: irrigation with wastewater twice in whole experimental period, I_3: irrigation with wastewater in whole experimental period) and six levels of wastewater percentage (C_1: 15% wastewater, C_2: 30% wastewater, C_3: 45% wastewater, C_4: 60% wastewater, A: pure water and P: pure wastewater). The soil characteristics are given in Table 1.

Experimental plots were sown at 8 plants per square meter. Analytical data of the treated wastewater and well water are shown in table 2. Irrigation was applied during growing season according to treatments.

Crop sampling and calculation

Plants in central rows at each plot were harvested to determine the root yield in December 2013. The yield components included root diameter and root length were obtained from ten selected plants in each plot.

Statistical analysis

Data analyzed was done by MSTAT-C software. The ANOVA test was used to determine significant

($p<0.05$) treatment effect and Duncan Multiple Range Test to determine significant difference between individual means.

Table 1. Soil properties measured prior to the initiation of the experiment.

Depth (cm)	Soil texture	pH	EC (dS m^{-1})	OM
0-40	Loam-clay	7.98	1.74	2.35%

Table 2. Chemical characteristics of treated leaven factory wastewater and well water.

Fe(mg/l)	K(meq/l)	P(mg/l)	pH	EC(dS/m)	Wastewater percentage	Well water percentage
0.453	0.173	0.136	7.62	0.63	0%	100%
0.826	3.61	8.61	7.83	1.42	15%	85%
1.163	7.25	21.37	8.14	2.36	30%	70%
1.094	9.84	37.43	8.39	4.15	45%	55%
2.357	13.59	54.65	8.52	5.21	60%	40%
2.741	22.71	142	7.22	7.82	100%	0%

Results and discussion

Results of this study showed that number of irrigation with wastewater had significant effect on root length, sugar percentage, sugar yield and root yield of sugar beet. The effect of wastewater percentage was significant on mentioned treats of sugar beet (Table 3).

Data presented at table 3 indicated that the number of irrigation with wastewater × wastewater percentage only at the root yield was significant.

Table 3. Analysis of variance of yield and yield components as affected by number of irrigations with wastewater and wastewater percentage treatments.

S.O.V	Df	Root length	Root diameter	Sugar percentage	Sugar yield	Root yield
Replication	2	6.298^{**}	32892.882	0.205	0.150^{*}	18.886^{**}
Number of irrigation with wastewater (A)	2	11.709^{**}	32622.806^{ns}	1.418^{**}	0.799^{**}	305.309^{**}
Wastewater percentage (B)	5	7.741^{**}	32850.614^{ns}	3.183^{**}	0.203^{**}	118.314^{**}
Number of irrigation × wastewater percentage (A×B)	10	0.771^{ns}	32682.365^{ns}	0.308^{ns}	0.025^{ns}	14.213^{**}
Error	34	0.830	32700.176	0.220	0.042	3.298
CV (%)		2.34	12.54	3.62	2.32	2.54

Ns: Non significant; **, *: significant at 1% and 5% probability

Root length

The highest root length obtained from irrigation with wastewater in whole experimental period and the root length obtained from irrigation with wastewater once in whole experimental period (Fig. 1). Esmailian *et al* (2011) concluded that ear length and ear diameter were appreciably higher in plants grown in treated wastewater compared with well water. This might be due to availability and better utilization of nutrients from wastewater.

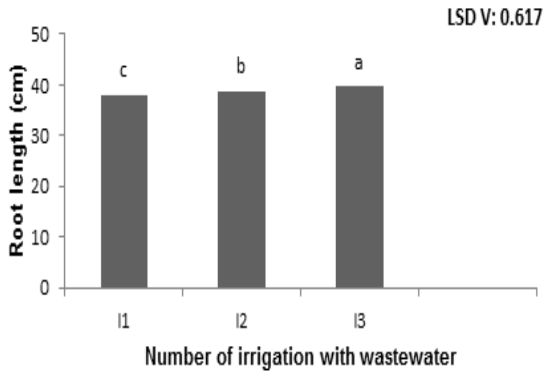

Fig. 1. Effect of number of irrigation with wastewater treatment on root length. Different letters expose significant difference at 5% probability.

The highest root length was obtained from irrigation with 45% wastewater and the lowest root length obtained from irrigation with pure wastewater (Fig. 2). Esmailian *et al.* (2011) demonstrated that wastewater irrigation and fertilizer treatments were very effective on the yield components. Among yield components, wastewater had the most influence on the 1000-grain weight and increased it 19.1% than well water.

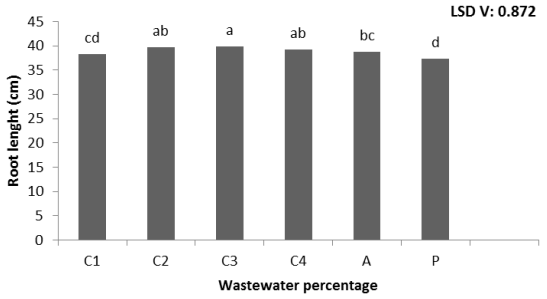

Fig. 2. Effect of wastewater percentage treatment on root length. Different letters expose significant difference at 5% probability.

Sugar percentage

Among wastewater percentage treatments, irrigation with pure water in whole experimental period showed the highest sugar percentage and the lowest sugar percentage obtained from irrigation with 100% wastewater (Fig. 3). Effects of treated sewage effluent irrigation on increase the protein content in ryegrasses, wheat and forage corn were observed (Day *et al.*, 1974; Quin and Woods, 1978; Mohamad and Ayadi, 2004).

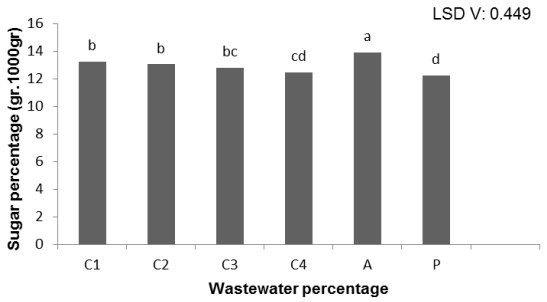

Fig. 3. Effect of wastewater percentage treatment on Sugar percentage. Different letters expose significant difference at 5% probability.

Sugar yield

According to means comparing recognized that the use of irrigation with wastewater in whole experimental period in comparison with irrigation with wastewater once and twice in whole experimental period, result in the increase of sugar yield (Fig. 4). Tavassoli *et al.* (2010) reported that irrigation with wastewater caused increasing the grain yield in corn.

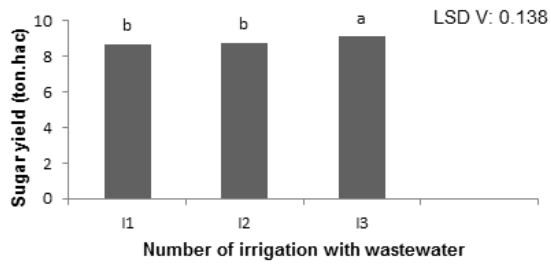

Fig. 4. Effect of number of irrigation with wastewater

treatment on sugar yield. Different letters expose significant difference at 5% probability.

The sugar yield of those treatments which used irrigation with 45% wastewater was higher than treatments which used irrigation with pure water (Fig. 5). Almasi *et al.* (2014) demonstrated that number of irrigation with wastewater during growth season had significant effect on grain yield of corn but wastewater percentage did not have significant effect on grain yield of corn.

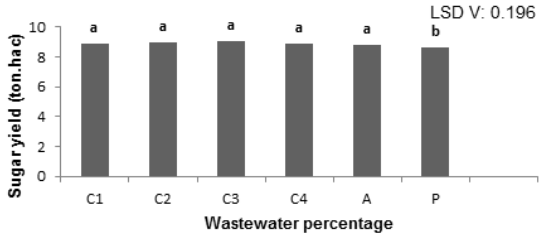

Fig. 5. Effect of wastewater percentage treatment on Sugar yield. Different letters expose significant difference at 5% probability.

Root yield

The root yield of those treatments which used irrigation with wastewater in whole experimental period was higher than treatments which used irrigation with wastewater once and irrigation with wastewater twice in whole experimental period (Fig 6). Drawing upon the findings of the current study, Esmailian *et al* (2011) reported that wastewater irrigation show a significant effect on grain yield of corn.

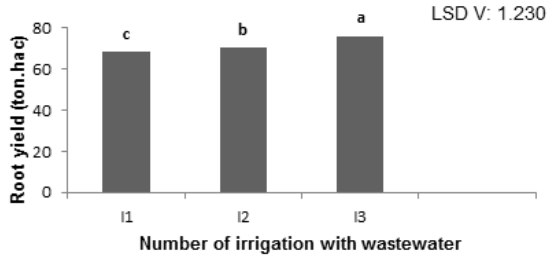

Fig. 6. Effect of number of irrigation with wastewater treatment on root yield. Different letters expose significant difference at 5% probability.

The highest root yield obtained from irrigation with pure water and the lowest root yield obtained from irrigation with 100% wastewater (Fig. 7).

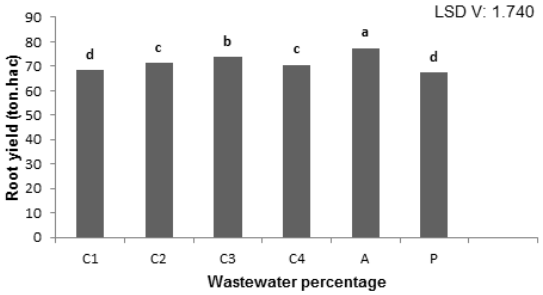

Fig. 7. Effect of wastewater percentage treatment on root yield. Different letters expose significant difference at 5% probability.

The highest root yield obtained from irrigation with wastewater in whole experimental period × 45% wastewater treatment and the lowest root yield obtained from irrigation with wastewater once in whole experimental period × 15% wastewater. It decreased biological yield 17.86% than pure water (Fig. 8). Almasi and kouche bagh (2014) reported that number of irrigation with wastewater had significant effect on biological yield of wheat but wastewater percentage did not have significant effect on biological yield of wheat.

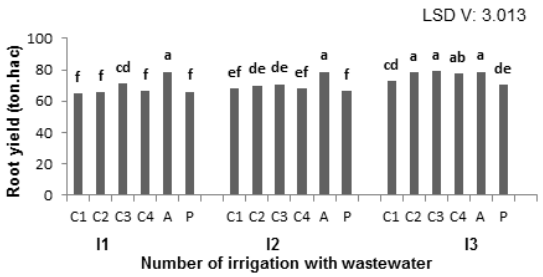

Fig. 8. The interaction effects of number of irrigation with wastewater and wastewater percentage on cob weight. Different letters expose significant difference at 5% probability.

Conclusion

The results in this experiment showed that irrigation with wastewater in whole experimental period significantly increased root yield, sugar yield and root length but it did not have significant effect on root diameter.

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