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Influence of irrigation with wastewater on yield and yield component of wheat

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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 wheat (*Triticum aestivum* L.) was studied during the growing season of 2012. Three, irrigation levels (I_1: irrigation with wastewater once in whole experimental period, I_2: irrigation with wastewater twice in whole experimental period and I_3: irrigation with wastewater in whole experimental period) and six wastewater percentage levels (C_1: 15% wastewater, C_2: 30% wastewater, C_3: 45% wastewater, C_4: 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 irrigation with wastewater did not have significant effect on plant height, grain number per spike, grain yield and harvest index while it had significant effect on spike number, 1000-seeds weight and biological yield. Also results showed that wastewater percentage did not have significant effect on spike number, grain number per spike, grain yield, biological yield and harvest index although it had significant effect on plant height and 1000-seeds weight. The maximum increase of biological yield was observed in irrigation with wastewater in whole experimental period.

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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). 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 yields as much or more than a combination of tap water and chemical fertilizer (Lopez *et al.*, 2006; WHO, 2006; Kiziloglu *et al.*, 2007).

Since agriculture involves consumptive use of water, therefore, the use of additional water resources of marginal quality like, the wastewater can increase the volume of water available for irrigation. It has a high potential for reuse in agriculture as a source of irrigation, especially in arid and semiarid areas. It is currently used to irrigate crops in Middle East, North and South Africa, South America, Asia, Australia and in parts of Europe (Bastian, 2006). Besides serving as a source of irrigation water, it contains many essential nutrients which may increase the yield of the crop and at the same time may substitute or even lower the fertilizer requirement of the crop and may also contribute to environment security by reducing the pollution level of surface waters as well as ground water (Tak *et al.*, 2012).

Domestic wastewater rich in organic materials and plant nutrients are finding agricultural use as a cheap way of disposal. Use of domestic wastewater in agriculture may contribute considerable to alleviate the pressure in using fresh water resources. Wastewater from different sources contains considerable amount of organic matter and plant nutrients (N, P, K, Ca, S, Cu, Mn & Zn) and has been reported to increase the crop yield (Pathak *et al.* 1998; Pathak *et al.* 1999; Ramana *et al.* 2001; Lubello *et al.* 2004; Nagajyothi *et al.* 2009; Nath *et al.* 2009). 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. Kiziloglu *et al* (2008) showed that wastewater irrigation affected significantly soil chemical characteristics and nutrient content of cauliflower and red cabbage. Also soil salinity, organic matter, available P and microelements increased as influenced by wastewater treatment. Wheat (*Triticum aestivum* L.) is the most important food grain in the world. It is a staple food for millions of people and major supplement in the human diet containing carbohydrates, protein, minerals and amino acids (Weigand, 2011). The objective of this study was assessed the impacts of leaven factory wastewater irrigation on yield and yield component of wheat.

Materials and methods

This study was conducted at the experimental farm where is located at Tabriz (38° 18′ N, 45° 7′ E) during 2012 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 with Pishgam cultivar at 400 seeds 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 grain yield and biological yield in November 2012. The yield components included grain number per spike, spike number, 1000-seeds weight 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.

Results and discussion

Results of this study showed that number of irrigation with wastewater had significant effect on spike number, 1000-seeds weight and biological yield of wheat. The effect of wastewater percentage was significant on plant height and 1000-seeds weight of wheat (Table 3).

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%

Data presented at table 3 indicated that effect of number of irrigation with wastewater × wastewater percentage was not significant on plant height, grain number per spike, spike number, 1000-seeds weight, grain yield, biological yield and harvest index (Table 3).

Table3. Analysis of variance of yield and yield component as affected by number of irrigation with wastewater and wastewater percentage treatments.

S.O.V	df	Plant height	Grain number per spike	Spike number	1000-seeds weight	Grain yield	Biological yield	Harvest index
Replication	2	4.308	5.938*	7005.50	6.864	14796.094	967837.772*	0.057
Number of irrigation with wastewater (A)	2	48.084ns	0.058ns	16287.389**	10.027*	4034.217ns	1035284.906**	0.156ns
Wastewater percentage (B)	5	340.861**	1.001ns	2205.411ns	10.429**	14817.707ns	129819.479ns	0.161ns
Number of irrigation × wastewater percentage (A×B)	10	16.410ns	1.200ns	3063.833ns	3.050ns	16204.893ns	135361.893ns	0.150ns
Error	34	18.817	1.484	2827.873	2.713	15720.124	186928.419	0.136
CV (%)		5.86	3.39	10.05	4.97	6.28	3.81	6.47

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

Plant height

The highest plant height obtained from irrigation with 60% wastewater and the lowest tassel weight obtained from irrigation with 100% wastewater (Fig. 1). Feizi and Rezvani moghadam (2008), showed that irrigation with sewage water has caused increasing tailoring, steam length, panicle length and number of spikes in rice. Rahimi *et al* (2012), found that permanent sewage treatment had the maximum steam length and typical water treatment had the lowest steam length.

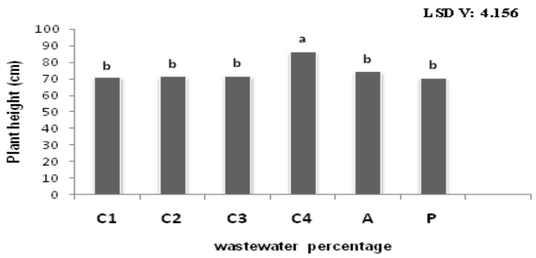

Fig. 1. Effect of wastewater percentage treatment on plant height. Different letters expose significant difference at 5% probability.

Spike number

According to means comparing recognized that the use of irrigation with wastewater twice in whole experimental period in comparison with irrigation with wastewater once and irrigation with wastewater in whole experimental period, result in the increase of spike number (Fig. 2).

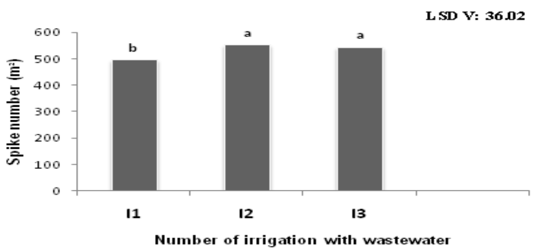

Fig. 2. Effect of number of irrigation with wastewater on spike number. Different letters expose significant difference at 5% probability.

1000-seeds weight

The 1000-seeds weight of those treatments which used irrigation with wastewater twice in whole experimental period was higher than treatments which used irrigation with wastewater once and irrigation with wastewater in whole experimental period (Fig 3). Similar results were reported by Day *et al.* (1979) who observed that wheat irrigated with wastewater produced taller plants, more heads per unit area, heavier seeds, higher grain yield than did wheat grown with pump water alone. They attributed this increase to the nitrogen, phosphorous, potassium and another nutrient elements which added by wastewater to the soil.

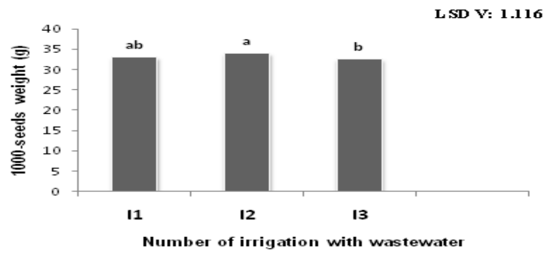

Fig. 3. Effect of number of irrigation with wastewater on 1000-seeds weight. Different letters expose significant difference at 5% probability.

The maximum of 1000-seeds weight was observed in irrigation with 60% wastewater and the minimum of 1000-seeds weight was observed in irrigation with 30% wastewater (Fig. 4). Mohamad and Ayadi (2004) reported that grain weight of corn were increased significantly by wastewater irrigation compared to pure water irrigation.

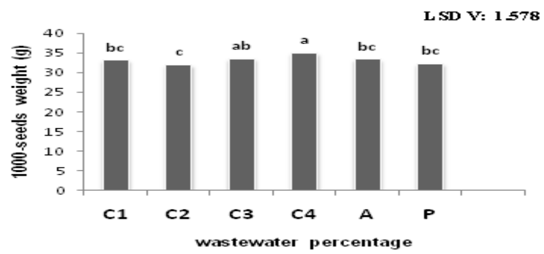

Fig. 4. Effect of wastewater percentage treatment on 1000-seeds weight. Different letters expose significant difference at 5% probability.

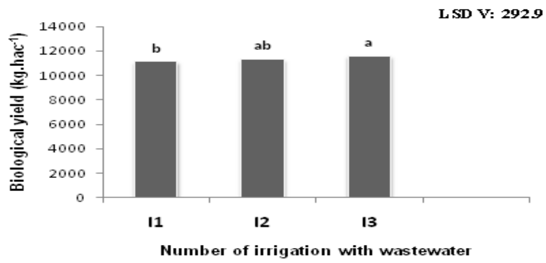

Fig. 5. Effect of number of irrigation with wastewater on biological yield. Different letters expose significant difference at 5% probability.

Biological yield

Among all number of irrigation with wastewater treatments, irrigation with wastewater in whole experimental period had the highest and irrigation with wastewater once in whole experimental period had the lowest effect on biological yield of wheat (Fig 5). The results showed that cotton yield irrigated with wastewater was more than that in irrigation with typical water. They also declared in a field review that of produced green forage in barley 112%, wheat 263% and avena 249% in treatment of sewage in comparison of irrigation with typical water was more (Papadopoulos and Stylianon, 1991).

Conclutions

Study data demonstrated that wheat yield components of Pishgam cultivar can be increased by application of 60% wastewater and irrigation with wastewater twice in whole experimental period and also wheat biological yield can be increased by application of irrigation with wastewater in whole experimental period.

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