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The effect of quality and different levels of irrigation on the growth and yield of maize seeds in Kerman, Iran

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Abstract

The present study aims to investigate the effect of wastewater on the yield of maize seeds based on randomized blocks with three frequencies. The treatments were applied in terms of two types of water qualities (Q1: well water and Q2: urban wastewater) as primary factors and three percent of water need (I1=100, I2=85, and I3=70) were regarded as secondary factors. The results showed that the treatment using purification wastewater, show more significant yield level than the other treatment approach using well water. The application of a 100-percent water need with wastewater in comparison to the treatment with an 85-percent water need culminated in a 4.6 percent increase in production yield, 6.7 percent boost in seed weight, 4.4 percent increase in the number of seeds in a row, as well as 3.5 percent boost in the number of seed rows. Also, the study indicated that the amount of consumable water in the treatment with 85-percent water need was reported to be 2420 square meters less than the control treatment. Furthermore, the water level of efficiency increased by 11 percent for the treatment with 85-percent water need. Hence, the study showed that irrigation with wastewater brings about a higher significant level of production for maize seeds rather than irrigation with well water.

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Introduction

Due to the unbalanced distribution of water supply, the demand for water in areas where more than forty percent of the earth population inhabit has surpassed the amount of available water resources. Moreover, the reported data in the current years for water demand illustrate critical water supplies in many countries (Qadir *et al.* 2007). Therefore, efficient policies and strategies in terms of water usage along with a well-grounded technology are required to improve the situation. These factors have prompted the authorities to think about providing new water resources which are significantly economic in agriculture. To this end, urban wastewater is regarded as a very important asset of water resources since the rapid growth in world population and public health have culminated in a dramatic increase in the consumable level of water usage which in turn have resulted in a high level of wastewater (Sacco *et al.* 2012).

Iran has also, experienced a high level of water demand and in turn a high amount of wastewater due to the development of cities across the country. Hence, the increase in wastewater has caused many problems in both urban and rural areas such as health issues, environmental pollution, natural water imbalance, as well as groundwater increase. Therefore, with reference to the priority in wastewater reuse in agricultural irrigation (Heidarpuor *et al.* 2007) and with regard to the national strategy in protecting environmental health and saving water resources, necessary facilities for the collection and treatment of urban and industrial wastewater should be established in order to improve the environmental pollution (Jahantigh, 2008).

Since wastewater is considered as low-quality water supply, the application of such water to agricultural sector entails a specific kind of management to decrease environmental and health risks to the minimum level for human beings, soils, plants, as well as surface and groundwater supplies. In case we are able to combine the application of wastewater with sufficient irrigation methods, we can pave the way for improve health, pollution, and water supply crises. On the one hand, the proper utilization of wastewater develops the growth of plants; on the other, it prevents environmental pollution. In addition, wastewater usage reduces both surface and groundwater supplies and decreases the consumption of chemical fertilizers through providing sufficient level of nutritional materials for plants. Hence, wastewater utilization is applied to both industrial and under-developed countries across the world (Pir Saheb *et al.* 2013).

In this regard, in a study carried out on maize, the researchers reported that treatment with wastewater with reference to maize seeds led to the highest level of efficiency during all growth stages of maize (Aiello *et al.* 2007). In another study on maize, the researchers concluded that wastewater irrigation increased the growth of maize three times more than well water irrigation. They demonstrated that irrigation with wastewater caused an increase in maize height, the green color of its leaves, as well as flowering period of time (Jenkis *et al.* 1994).

Furthermore, another study investigated the effects of using urban wastewater of Zabol city in Iran along with livestock and chemical fertilizers for finding the concentration of different elements as well as scrutinizing the yield of forage and maize seeds. The study was carried out in terms of create farmlands based on randomized blocks with three frequencies during 2008 to 2009 in Zabol Institute of Agriculture. The researchers concluded that although the seed yield was caused by the positive impact of wastewater on different stages of seed yield, the existence of sufficient amounts of the elements such as Nitrogen, Phosphorous and Potassium in wastewater led to such a positive effect (Tavasoli *et al.* 2010).

Therefore, it seems that we are able to utilize wastewater as a reliable source for providing water, specifically in dry as well as semi-dry lands which suffer from severe shortage of water resources. In case we pave the way for using wastewater for irrigation in the agricultural sector, we may be able to provide the sufficient grounds for saving our water resources and chemical fertilizers as well as reducing water expenses. To this end, the present study aims to investigate the effect of refined wastewater on the yield of maize seeds under the conditions of applying different irrigation levels in comparison to furrow and well water irrigation based on randomized blocks with three frequencies.

Materials and method

Field conditions and treatments

The present study aimed to investigate the effect of wastewater on the maize seed yield in Kerman city with 57 degrees longitude, 6 minutes of east, 30 degrees of latitude, 29 minutes of north, and altitude of 1756 meters above sea level in an area of 530 square meters based on randomized blocks with three frequencies in 2013. In this study, two types of water qualities (Q_1: well water and Q_2: urban refined wastewater) as primary factors and three percent of water need (I_1=100, I_2=85, and I_3=70) were regarded as secondary factors. In addition, the treatments were applied to create with the width of four meters and length of six meters (including four rows of cultivation with the distance of 100 cm from one another).

Estimated of water requirement

Also, the water requirement of the plant was determined by modified Penman-Monteith formula by FAO and crop coefficient (Alizadeh, 2008). The parameters related to Penman-Monteith formula were obtained from Kerman weather station and the crop coefficient was determined with reference to corn crop coefficient curve for periods of irrigation during the growing season and with regard to the guidelines in FAO publication No. 56 (Richard *et al.* 1998).

Calculate of irrigation interval

In order to calculate the irrigation interval, a soil sample was obtained; hence, its physical and hydraulic parameters were determined. Accordingly, the parameters of moisture percentage within field capacity, wilting point, maximum allowable depletion were reported to be 31, 12.6 and 65 percent, respectively. In this regard, the irrigation interval for treatment with furrow irrigation was determined according to soil texture and water retention in the soil during 6 days which was roughly proportional to the average irrigation in the region. Besides, the volume of water required for irrigation was determined based on moisture percentage at field capacity, wilting point, and root depth using Equation 1 (Alizadeh, 2008):

$$d_i = d_r(\theta_{fc} - \theta_{pwp})\ MAD \qquad (1)$$

Where d_i: Gross irrigation demand, θ_{fc}: the percentage of soil moisture at field capacity point, θ_{pwp}: moisture percentage at wilting point and MAD: the maximum allowable depletion of the soil.

Chemical characteristics of soil, water, and wastewater

Tables 1 and 2 show some of the chemical characteristics of soil, water, and wastewater (along with the standards). The amount of water applied in the secondary treatments were identical, so that such amount in the treatments with 100, 85, and 70 percent of water requirement were calculated to be 16100, 13680, and 11270 cubic meters per hectare, respectively.

Measured parameters

a) The yield of yielding which was measured through the two rows of each plots and the two adjacent rows were deleted, namely as the border.

b) The parts of yielding which included the seed weight, the number of seeds per row, and the number of rows of seed. For measurement purposes, the two middle rows of cultivation were used.

c) Water consumption was measured through a volumetric flow.

d) Water use efficiency of irrigation was obtained through dividing the level of obtained yield with the assigned water to each treatment. The obtained data were analyzed using MSTAT-C.

Results and discussion

Analysis of Variance

Table 3 shows the analysis of variance with reference to the effects of the quality of irrigation water of A as the main factor, of B as the secondary factor for irrigation treatment levels, as well as AB as the interactional effect among them, on the performance of water use efficiency, the seed weight, the number of seeds per row, and the number of seed rows per ear. These results indicate that the effect of irrigation treatment, the quality of irrigation water, as well as the interactional effect of the two treatments are significant at 1 percent for all the factors under study except the effect of the interaction between the two factors on the number of seeds in each row and the number of rows of seed.

Table 1. Physical and chemical properties of the soil of experimental field.

Soil depth (cm)	Mg	Ca	Na	pH	Hydraulic Conductivity	Sand (%)	Silt (%)	Clay (%)	SAR
	(mg/l)				(ds/m)				
0-30	4.3	5.2	0.6	7.2	0.8	35	35	30	0.29

Table 2. Chemical characteristics of well water, wastewater and wastewater pollution standard boundary for agricultural purposes[1].

parameter	well water	wastewater	standard boundary pollution in agriculture purposes
pH	6.1	6.9	6-8.5
EC (dS/m)	1.5	1.1	-
Ca (meq/l)	23.4	135.2	-
Mg (meq/l)	15.1	79.2	100
P (meq/l)	-	17.6	-
K (meq/l)	-	25.4	-
K (meq/l)	-	10.2	-
CL (meq/l)	-	6.3	-
BOD (ppm)	-	34	100
COD (ppm)	-	51	200

Iranian environmental Protection Agency's standard.

Yield and Water Use Efficiency

One of the environmental factors affecting the quantity and quality of crops is plant nutrition; therefore, the use of fertilizer can increase forage quality. Wastewater is regarded as a rich source of nutritional materials with a high level of nitrogen. Not only it is economical in terms of reducing chemical fertilizers, but also it improves forage quality (Blum *et al.* 2012).

The use of wastewater in agriculture not only provides the required water for crops, but also supplies sufficient nutritional materials for plants (Sou Dakoure *et al.* 2013). Therefore, the analysis of the factors under study indicates the superiority of utilizing wastewater over well water in planting and cultivating maize seeds in the city of Kerman because of the following reasons: crop yield and water consumption efficiency were reported to be 29.8 and 28.9 percent more than the treatment which used well water (Fig.1.). It can be understood that the nutritional materials and organic matter in wastewater are decomposed by micro-organisms existing in soil which increase soil humus and improve physical, chemical and fertile properties of soil eventually leading to increased level of yield (Khai *et al*. 2008; Heidarpour *et al*. 2007).

Yield components

1000-grain weight, number of seeds in each row and the number of rows of seed in which were reported to be 13.8, 14.8, and 22.7 percent more than the treatment which used well water, respectively (table 4).

Table 3. Summary of analysis of variance.

SOV	d.f.	yield	1000- grain weight	water use efficiency	number of seeds in each row	number of rows of seed
Rep	2	142159.31	53.09	0.0415	29.069	19.51
A	1	49872578.12 **	289.09 **	0.027**	196.07 **	49.11 **
E_1	2	41897.07	5.32	0.002	0.16	0.97
B	2	12453894.28**	3109.78**	0.087**	201.27 **	64.25**
AB	2	874198.45**	11.97**	0.001**	2.97 ns	1.32 ns
E_2	6	21754.87	0.46	0.001	0.098	0.59

Table 4. Mean comparison of the characteristics main factor.

Treatments	number of rows of seed	number of seeds in each row	1000- grain weight (gr)
Q_1	17.36 b	42.37 b	2777.73 b
Q_2	22.45 a	49.74 a	322.21 a

In a study the effects of water and wastewater ratios on corn yield, five levels of refined wastewater were compared with well water. The results of the study showed that the more the amount of wastewater is, the better the yield of crop will be. The study concluded that only 70 percent of refined wastewater equaled the treatment with well water (Esmaeili *et al.* 2011).

Considering the superiority of utilizing refined wastewater to using well water in all parameters investigated, the results of different levels of wastewater irrigation treatments are as follow:

Applying the irrigation level of 85 percent water demand in the conditions of utilizing refined wastewater in comparison to 100 percent water demand in the same conditions caused 11 percent of increase in terms of the efficiency of water consumption, 4.6 percent decrease with regard to yield, 6.7 percent reduction in 1000-grain weight, 4.4 percent decrease in the number of seeds in each row, 3.5 percent reduction in the number of rows of seed and last but not least a reduction of 2420 square meters of water consumption(table 5 and fig.2.). In addition, the high performance and yield of 80 percent of water demand enjoys positive effects plant components which eventually leads to the good performance of the treatments (Khai *et al.* 2008).

Table 5. Mean comparison of the studied factors affecting interaction.

Treatments	number of rows of seed	number of seeds in each row	1000- grain weight (gr)
I_1Q_1	20.65 a	46.8 a	297.01 c
I_1Q_2	25.81 a	55.2 a	356.21 a
I_2Q_1	18.7 a	43.2 a	283.85 d
I_2Q_2	24.91 a	52.8 a	332.45 b
I_3Q_1	12.72 a	37.1 a	252.32 e
I_3Q_2	16.62 a	41.2 a	277. 98 d

Moreover, the application of 70 percent of water demand in the conditions of refined waste water in comparison to applying 100 percent of water demand caused reduction in the following parameters: 54.9 percent in performance and yield, 35.6 percent water use efficiency, 22 percent of 1000-grain weight, 25.4 percent of number of seeds in each row, 35.6 percent of the number of rows of seed which totally led to saving 4830 cubic meters of water per hectare (table 5 and fig.2.). The reason behind it can be assigned to the high level of plant dryness which reduces its leaf size, growth, as well as yield (Payero *et al.* 2006).

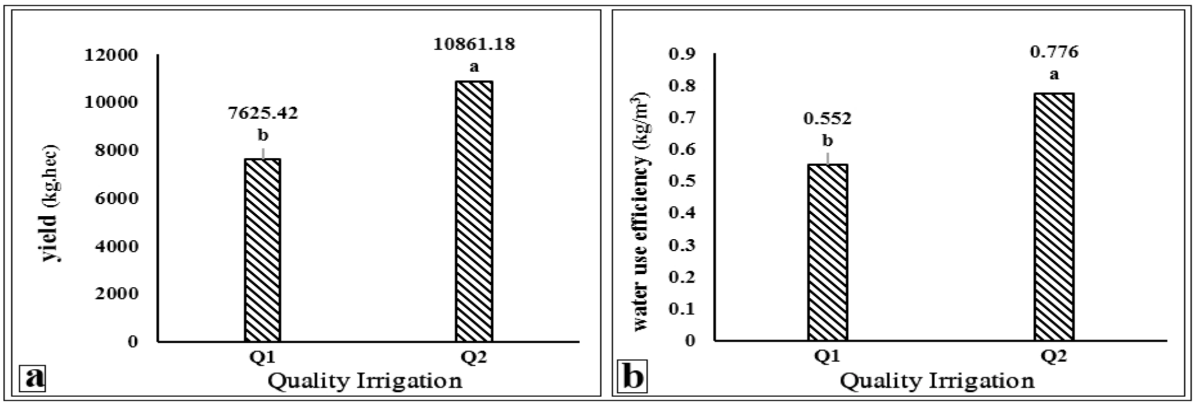

Fig. 1. Mean comparison of yield (a) and water use efficiency (b) under the main factor.

In another study the effects of wastewater on the level of wheat crop and concluded that urban refined wastewater can be considered as a prominent source as well as an alternative way for meeting the water demands in agriculture since the existence of nutritional materials such as phosphorus and nitrogen in urban wastewater comparing groundwater resources causes increased production and can prevent the overuse of chemical fertilizers (Aiello *et al.* 2007).

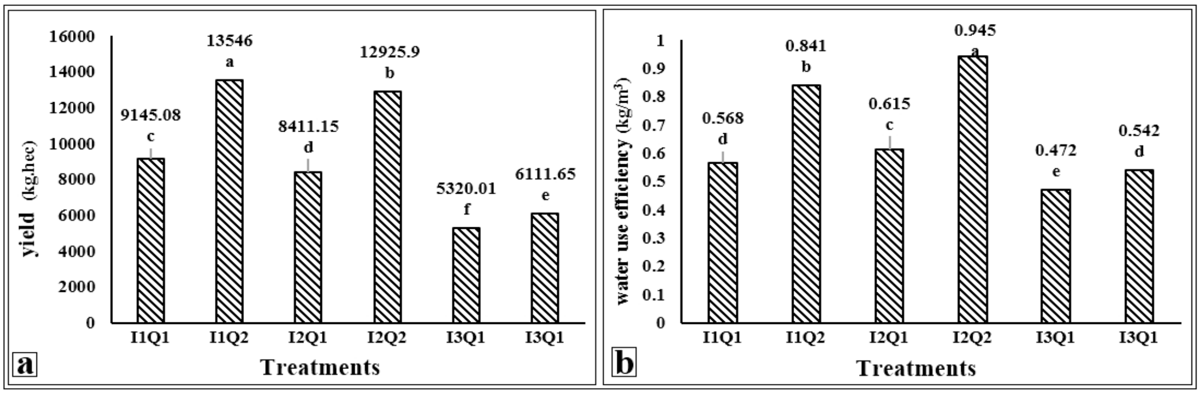

Fig. 2. Mean comparison of yield (a) and water use efficiency (b) is influenced by the interaction of two factors.

Besides, in another study the effects of using refined wastewater of Zabol city in Iran along with livestock and chemical fertilizers on the concentration of different elements and forage and maize seed yield, the researchers concluded that using wastewater significantly increases the fresh forage, dry forage, as well as seed yield which were reported to be 8.3, 23.1, and 39.2 percent more than normal irrigation, respectively (Tavasoli *et al.* 2010).

Conclusions

The present study aimed to investigate the effect of refined wastewater on the yield of maize seeds based on randomized blocks with three frequencies. The treatments were applied in terms of two types of water qualities as primary factors and three percent of water need was regarded as secondary factors. The results showed that the application of refined wastewater as a irrigation method for agricultural crops causes an increase in crop yield because of the beneficial of a variety of nutritional materials in comparison to the application of normal water. In addition, the study demonstrated that among the applied levels in wastewater irrigation, the highest yield and performance was seen in the treatment with 100 percent of water demand. Hence, it illustrated the sufficient level of moisture for the growth period of the plant under study. In this regard, the utilization of wastewater in the treatment with 100 percent of water demand for cultivating and growing maize in the city of Kerman in Iran can be considered as one of the efficient ways to increase the level of plant yield and performance.

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