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Evaluation of Performance Barley Cultivation Using Different Types of Water Sources

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Abstract

The main objective of research is to study the impact of dairy effluents and groundwater on barley (Hordeum vulgare) growth, yield, and soil salinization. The experiment was conducted at Al-Raid research station/ the national center for water resources management, for the winter season (2018-2019). three irrigation treatments – T_1: irrigation by treated dairy wastewater effluents, T_2: irrigation by groundwater, T_3: irrigation by river water (control). There was a significant effect of irrigation water quality at (p = 0.05) on the height and grain yield of barley. The highest mean for barley length was recorded for T_1 in the middle of the season and was (73.7 cm), while T_2 produced the highest mean for barley length at the end of the season and was (102.1 cm). T_2 produced the highest grain yield (1920 kg/ha), whereas T_3 produced the lowest grain yield (1310.7 kg/ha). For all the treatments, soil EC recorded higher values at the end of the season compared with the pre-study values. Soil pH was not affected by irrigation with the treated wastewater and groundwater. The concentrations of (Ca^{2+}, Mg^{2+}, Cl^-, $SO4^{2+}$) increased for T_1 and T_2. Meanwhile, there was a slight decrease in the concentration of these elements for T_3. This study revealed that barley showed higher growth and yield under treated dairy wastewater and groundwater irrigation.

Keywords: Barley, dairy wastewater, groundwater, yield, Soil salinization.

إمكانية استخدام مصادر مائية مختلفة لري الشعير

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المستخلص

يهدف العمل الحالي إلى دراسة تأثير مخلفات الألبان السائلة والمياه الجوفية على نمو الشعير (Hordeum vulgare) والانتاجية وتملح التربة. أجريت التجربة في محطة أبحاث الرائد / المركز الوطني لإدارة الموارد المائية ، لموسم الشتاء (2018-2019). تم استخدام ثلاث معاملات للري - T1: الري بمياه الصرف الصحي المعالجة من معمل البان ابوغريب ، T2: الري بالمياه الجوفية ، T3: الري بمياه النهر. كان هناك تأثير فعلي ($p = 0.05$) لنوعية مياه الري على ارتفاع النبات وانتاجية المحصول. حيث سجل أعلى متوسط لاطوال نبات الشعير للموسم الأول في منتصف الموسم وبلغ (73.7 سم) ، بينما سجل T2 أعلى متوسط لاطوال نبات الشعير في نهاية الموسم وكان (102.1 سم). بينما حققت المعاملة T2 أعلى انتاجية (1920 كغم / هكتار)، وحققت المعاملة T3 أقل انتاجية (102.1 كغم / هكتار). لجميع المعاملات الثلاثة ، سجلت الايصالية الكهربائية للتربة قيماً أعلى في نهاية الموسم مقارنة بقيم ما قبل الموسم الزراعي. لم يتأثر الرقم الهيدروجيني للتربة أثناء الري بمياه الصرف الصحي المعالجة والمياه الجوفية. اما بالنسبة لتراكيز Ca^{2+}, Mg^{2+}, Cl^{-}, $SO4^{2+}$ زادت في المعاملات (T1, T2) وانخفضت بمقدار طفيف في المعاملة T3. كما وبينت هذه الدراسة أن محصول الشعير أظهر نمواً وإنتاجية أعلى تأثير المعاملات T1 و T2.

الكلمات المفتاحية: الشعير ، مياه الصرف الصحي للألبان ، المياه الجوفية ، الانتاجية ، الترب المالحة.

1.0 Introduction

Iraq lies in an arid and semi-arid region, which is usually characterized by low annual rainfall and high evaporation rates. These conditions require efficient exploitation of the available water with high efficiency to obtain higher productivity. Iraq has long been facing major challenges represented by the decline in water flows due to neighboring countries projects in addition to climate change impact (Gaznayee, et.al.,2022). Unconventional water resources are considered promising resources that enhance agricultural resilience to water shortage. Reclaimed wastewater is inevitable in the agricultural sector in many arid and semi-arid regions where irrigation water supplies are inadequate to meet crop water demands (UN-Water, 2020).

The wastewater resulting from food industries in general, and dairy industry factories in particular, exert great pressure on water resources and the environment worldwide, due to the large amounts of water resulting from these activities, as water is used in every step of the dairy industry, including cleaning, sterilization, heating, cooling, and floor washing (Abdallh, 2016). The demand for dairy products in the country is expected to increase at a compound annual growth rate of 8% by the year 2025 (Frost & Sullivan, 2018).

The wastewater from dairy factories contains high concentrations of organic substances such as proteins, carbohydrates, and fat, high levels of biological oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), nitrates (NO_3), dyes, salts, in addition to variation in the pH level (Kaur, 2021). Wastewater reuse is a potential strategy to achieve the concepts of the sustainable development goals (SDGs) and to reduce the pressure on traditional water sources.

The majority of water resources all over the world are used by the agricultural sector (Lahlou , et.al.,2021). In Iraq, for example, agriculture is responsible for (75-80%) of the total water consumption (Al-Maliki , et.al.,2022). For this reason, there is a crucial need for using alternative water resources by farmers to ensure sustainability and to cope with the water scarcity dilemma (Qin & Horvath, 2020).

Using reclaimed wastewater in agriculture has many benefits and varies according to the natural conditions and the quality of the crops. It was used for cultivating strategic crops under the conditions of water shortage. Wastewater is an unconventional source that contains important nutrients for plants, which act as fertilizers (Alawsy et al., 2018).

The aim of the study is to find out the possibility of safely using treated wastewater for agricultural purposes produced by the Abu Ghraib dairy factory, which is a mixture of (water resulting from dairy manufacturing operations and factory wastewater), and groundwater on plant growth and soil properties compared with saline river water.

2.0 Materials and methods

2.1 Experimental site

A field experiment was implemented at Al-Raed Research Station- a specialized research station- affiliated with the Environmental Studies Department/National Center for Water Resources Management, located 20 km western Baghdad at longitude 44° 24' N, latitude 22° 33' E. Soil chemical properties of the site before planting are shown in Table (1). The soil of the site is characterized as sedimentary with a mixed texture of silty clay loam, classified as Typic Torrifluvents according to USDA soil taxonomy (USDA, 2014). The field was divided into 9 blocks (three treatments with three replications) in a completely randomized block design (CRBD), Figure (1).

Barley seeds (cv. Iba 99) were sown manually at a rate of 35 kg/ acre, cultivation and harvesting dates were 1/11/2018 and 4/4/2019, respectively. 50 kg of urea (46% N) was applied in two batches. The first application took place 7 days after germination. The second batch was applied after 30 days. 50 kg/acre of phosphate (21% P) was applied before planting. To test soil characteristics, representative samples were taken from the field at the pre and end of the study, then it was dried, ground, and passed through a sieve of 2 mm diameter.

Daily rainfall data were recorded during the study period using Campbell automatic weather station installed at the research site. The total amount of rain that fell during the experiment period amounted to 165.3 mm.

Table (1): The initial chemical properties of the soil used in the experiment

Soil horizon (cm	Ca^{2+}	Mg^{2+}	Na^{+}	Cl^{-}	Ec $dS.m^{-1}$	pH
	ppm					
25-0	940	532.4	1099	1620	17.4	7.5
50-25	860	520	980	1460	16.5	7.7
75-50	760	447	830	1196	12.4	7.8

2.2 Irrigation water sources

To study the effect of irrigation water, plants were subjected to one of the following three irrigation regimes: T_1: Diary wastewater irrigated treatment; T_2: well-irrigated treatment; T_3: river water (Control).

Treated wastewater used in the experiment was obtained from the effluent stream of (Abu-Ghraib general company of dairy products located 20 km western of Baghdad), which is discharged to Al-Saqlawia drainage. The main characteristics of this effluent were analyzed at the national center of water resources management laboratories, Table (2).

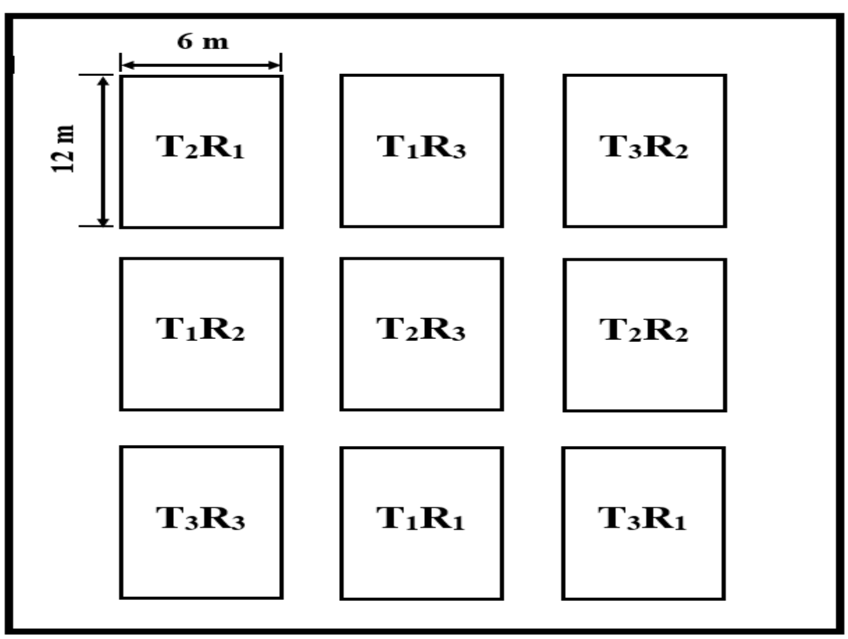

Figure (1): RCBD arrangement of the experimental site

Groundwater was used as a second source of irrigation water and was withdrawn from a well located inside Al-Raid research station. The third source was from Abu-Ghraib irrigation canal, which is fed from the Euphrates River and is generally used to irrigate almost all the experiments conducted inside the research station. The characteristics of the groundwater and river water used for irrigation are shown in Table (3).

Table (2): Mean values of the main characteristics of the treated effluent of the dairy wastewater treatment plant

	Property									
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	$SO4^{2+}$	Cl^{-}	$NO3^{-}$	COD	EC	
	ppm								$dS.m^{-1}$	
ated effluent	80	45	192	18	192	187	4.12	30	2.31	**7.77**
national regulation tewater reuse in irrig (3)/ 2012	450	80	250	100	200	200	50	100	-	4-8.6

Table (3): Characteristics of river water and groundwater used for irrigation (September/2018 – April/2019).

Water source		Property					
		Ca^{2+}	Mg^{2+}	Cl^{-}	SO_4^{+2}	EC	pH
		ppm				$dS.m^{-1}$	
River	mean	67.9	60.3	184.4	397.0	0.9	7.7
	Standard deviatic	19.5	44.0	102.7	92.8	0.2	0.1
Groundwater	mean	121.8	137.1	310.9	866.8	3.6	7.8
	Standard deviatic	26.5	27.0	27.9	213.2	0.2	0.2

2.3 Statistical analysis

The data were analyzed and statistical significance for the three replicates through one-way ANOVA test at ($p < 0.05$) using SPSS version 26, after conducting a normal distribution test using Shapiro-Wilk.

3.0 Results and discussion

3.1 Soil chemical properties

The effect of different irrigation water sources on soil salinization was evaluated at the mid and end of the season as shown in Table (4). The pH values remained neutral during the whole experiment period and for all the treatments. The EC values showed a pronounce increase for both T_1 and T_2 at the end of the season and ranged from (14.3-18.5 $dS.m^{-1}$) and (18.1-21.7 $dS.m^{-1}$), respectively, compared to the pre-study values (12.4- 17.4 $dS.m^{-1}$). In contrast, T_3 recorded lower EC values compared with the initial state and was ranging from (12.1-15.3 $dS.m^{-1}$). Many researchers suggest that the characteristics of water used for irrigation play a significant role in raising soil EC. (Farhadkhani et al., 2018) found that EC measured for plots irrigated with wastewater was higher than the EC before the irrigation due to the relatively high salinity of the wastewater. The same finding was observed by (Kallel et al., 2012), (Shakir et al., 2017). Ions (Ca, Mg, Cl, and SO4) tend to accumulate at the top of soil and record higher values compared to the deeper soil horizon. Also, these ions showed higher concentrations after the end of the study compared with the initial values for both T_1 and T_2. For T_1, the concentrations of (Ca, Mg, Cl, and SO_4) at the top soils were (977, 653, 2420, and 2208 ppm), T_2 recorded the highest values for these ions and were (1080, 818, 3160, and 4360 ppm), while T_3 has shown even lower concentrations for these ions in soil than the initial values and were (480, 372, 1470, and 2400 ppm). The decrease in soil salinization for T_3 could be related to the characteristics of irrigation water and rain fell during the experiment The accumulation of water-soluble cations and inions results in soil salinization. These water-soluble species are considered one of the most relevant parameters in the evaluation of wastewater suitability for irrigation (Ofori , et.al.,2021).

Table (4): Measured characteristics for the soil of the experiment site

atments	horizon (cı	pH	Ec	ppm			
T1	0 - 25	7.95	18.5	977	653	2420	2208
T1	25 - 50	7.9	20.1	865	580	1750	2310
T1	50 - 75	7.8	14.3	793	450	1212	2240
T2	0 - 25	7.8	21.7	1080	818	3160	4360
T2	25 - 50	7.85	18.7	896	794	2320	2668
T2	50 - 75	7.6	18.1	820	586	1575	1930
T3	0 - 25	7.4	15.3	480	372	1470	2400
T3	25 - 50	7.1	12.1	560	480	2730	2312
T3	50 -75	7.5	13.6	540	484	2170	2188

3.2 Plant height

The average heights of barley crop that were measured at the mid of the season (5/2/2019) and end of the season (17/3/2019) for all the treatments, are shown in Figure (2).

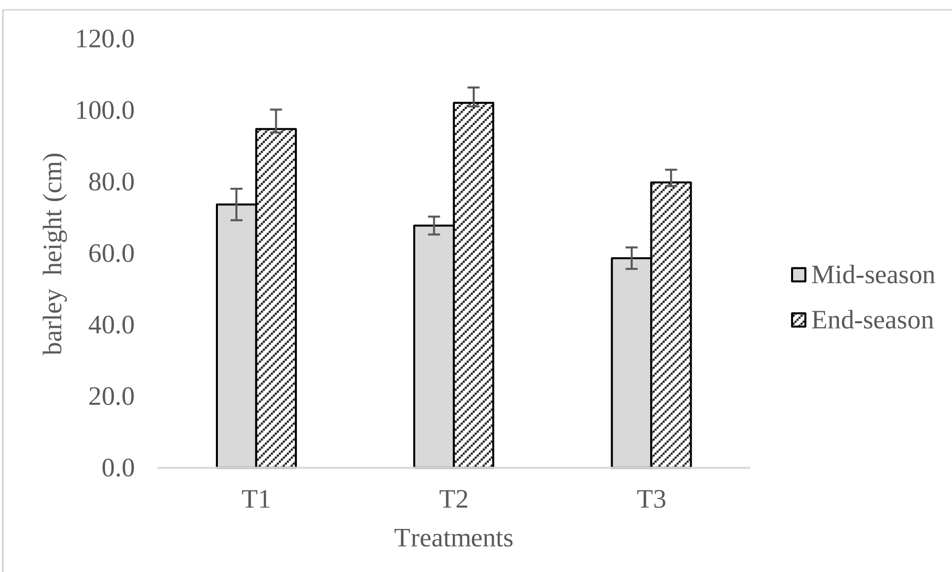

Figure (2): Average values for barley height at the mid and end of the season

In the mid of the season, the overall mean height for each treatment was (73.7, 67.8, and 58.6 cm) for (T_1, T_2, and T_3). The mean plant height increment was 25.8 and 15.7% in treatments T_1 and T_2, respectively compared to T_3. At the end of the season, the overall mean height for each treatment was (94.8, 102.1, and 79.3 cm) for (T_1, T_2, and T_3), and the mean barely height increased by 19.5 and 28.8% in treatment T_1 and T_2, respectively compared to T_3. Treated dairy wastewater and groundwater revealed higher plant growth than river water. This could be attributed to the high salt tolerant nature of barley (Hazzouriet al., 2018), and to the nutrients present in the treated dairy effluent and the groundwater which supported barely growth. This result is consistent with the result of (Hassan, 2011), (Alvarez-Holguinwt al., 2022). At 5% level of significance, the plant heights under the treatments T1, T2, and T3 were statistically significant at the mid and end of the season, Table (5).

Table (5): Results of the one-way ANOVA to test the significance between the three irrigation water on barley growth.

Property	**Treatment**	**Mean**	**Standard deviatio**	***P***	**F**
arley height- mid-sea (cm)	T_1	73.7	4.4	0.0001	44.448
	T_2	67.8	2.5		
	T_3	58.6	3.0		
arley height- end-sea (cm)	T_1	94.8	5.4	0.004	7.098
	T_2	102.1	4.3		
	T_3	79.3	3.6		

3.3 Yield response to irrigation water

Figure (3) shows the mean value of barley yield for T1, T2, and T3. Higher yield values for barley crops were achieved with T_1 and T_2, with slightly higher yield values for T_2 (1920 kg/ha) than T1 (1757.3 kg/ha). The lowest value of yield was obtained under river water irrigation and was (1310 kg/ha). (Karan & Subudhi, 2012) stated that high soil salinity has an adverse effect on crop productivity and resulting in high osmotic stress to a wide range of plants. However, in these experiments the relatively higher soil salinization didn't impact barely productivity, this could be attributed to the high tolerance of barely to soil salinization (Hazzouri , et.al.,2018). Similar findings were recorded by (Parmar et al., 2017), (Islam, 2015), (Hassan, 2011). In addition, wastewater resulted in a higher yield value than the control, this could be attributed to the nutrients and organic matter present in such irrigation water (Alawsy et al., 2018). The results of the study elucidate that barley yield responded significantly to irrigation water at significance level ($p < 0.05$), Table (6)

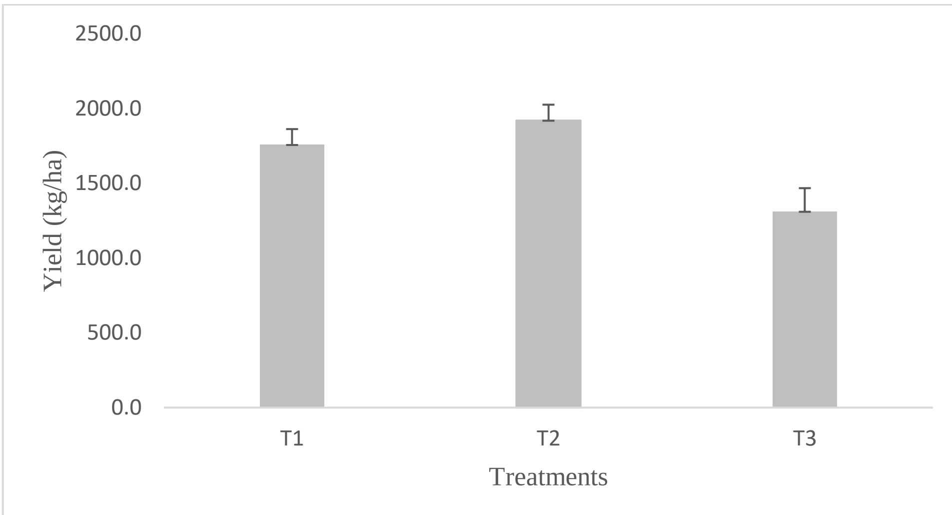

Figure (3):Average barley yield under the three different irrigation water.

Table (6): Results of the one-way ANOVA test to test the significance between the three irrigation water on barley yield

Property	Treatment	Mean	Standard deviati	*P*	F
Yield (kg/ha)	T_1	1757.3	105.6	0.003	19.028
	T_2	1920	106		
	T_3	1310	157.1		

4.0 Conclusions

- Irrigation of water quality exerted significant variation on the growth and yield attributes of barley.
- At the mid and end of the season, barley treatments irrigated with treated dairy wastewater and groundwater revealed higher growth than those irrigated with river water. This could be attributed to the nutritional effect of both treated dairy wastewater and groundwater.
- The yield barely significantly differed under different irrigation water qualities. The highest grain yield was obtained under irrigation by groundwater and treated dairy wastewater, respectively. While irrigation with river water gave a lower yield than the other two mentioned irrigation waters. This is due to soil improvement and nutrients added from irrigation water used for both T1 and T2.
- Soil salinization didn't seem to have an effect on barley growth and yield, as barley is considered one of the most tolerant crops.

5.0 Recommendations

- The effects of wastewater on the growth and yield of other crops need to be investigated.
- Changes in soil quality and associated impacts on the environment due to the application of wastewater need to be investigated.
- Field experiments using wastewater in different regions in Iraq under different agro-climatic conditions could be undertaken to confirm the findings of this study.
- It is necessary to control the salinity of the reclaimed wastewater used for irrigation to avoid soil salinization.
- We recommend that the study be repeated for another season, as it was not possible to implement it for another season due to repeated closure of the plant for reasons related to financial and logistics challenges.

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