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Effect of Different Irrigation Water Qualities on The Content of some Macro and Micronutrients in Leaves Fruit, as Well as Yield and Fruit Quality of Some Date Palm Cultivars in Al- Hassa Oasis, Saudi Arabia.

[1,2]Shahin M.M. and [3,4]Alhajhoj M. R.

[1]Soil and Water Dept., Fac. of Agric., Al-Azhar Univ., Cairo, Egypt.
[2]Al-Hassa Irrigation and Drainage Authority, Ministry of Agriculture, Al-Hasssa, Saudi Arabia.
[3]Department of Food and Nutrition Sciences. King Faisal University. Al-Hassa, Saudi Arabia.
[4]Date Palm Research Center of Excellence, King Faisal University, Al-Hsssa, Saudi Arabia.

ABSTRACT

The objective of this investigation is to study the impact of different irrigation water qualities: groundwater (GW), groundwater/ agricultural drainage water(GW+DW), ground water /tertiary-treated wastewater (GW+TTWW), and groundwater/agricultural drainage water/tertiary-treated wastewater (GW+DW+TTWW) on macro and micronutrients, some heavy metals' contents in leaves and fruits, as well as yield and fruit quality of three date palm cultivars (Khalas, Sheshi and Ruzeiz) at Tamr ripening stage. Trees were irrigated by different irrigation water qualities for 15 years in Al-Hassa Oasis, Saudi Arabia. The present study was carried out during 2010-2011 growing season on three, 20-years-old, date palm cultivars (Khalas, Sheshi and Ruzeiz).

The obtained results indicated that the use of (GW+TTWW), (GW+ DW +TTWW) and (GW+DW) for irrigation increased the content of the macronutrients (NPK) in the soils as compared to their content in soil irrigated by ground water (GW). Also similar increase was obtained in the content of micronutrients' (Fe, Mn, Cu and Zn) and the heavy metals, (Co, Cd, Pb, As and Ni) in the leaves as compared to their contents in leaves of date palm cultivars grown in the soil irrigated by groundwater.

The results also showed that the concentrations of the micronutrients Fe, Mn, Cu , Zn and heavy metals Co, Cd, Pb, As and Ni contents in the leaves of date palm cultivars are higher in the leaves of Ruzeiz cultivar as compared with those in Khalas and Shishi cultivars under different irrigation water qualities. There is a significant difference between the different irrigation water qualities on the content of the macronutrients and micronutrients in the fruits of different date palm cultivars. The highest increase in macro and micronutrients' contents in the fruits of date palm was observed by the use of (GW+DW+TTWW) followed by (GW+TTWW), and (GW+DW). While the lowest values were recorded by (GW).

The data indicated that the concentrations of the macronutrients (NPK) and the micronutrients (Fe, Mn, Cu and Zn) as well as the heavy metals (Co, Cd, Pb, As and Ni) in the fruits of date palm cultivars are higher in the fruits of Ruzeiz cultivar as compared with their contents in Khalas and Shishi cultivars under different irrigation water qualities.

The concentrations of both the micronutrient and the heavy metals in fruits of different date palm cultivars (Khalas, Sheshi and Ruzeiz) were within the range of the permissible limits according to the World Health Organization.

Key words: Irrigation water quality, agricultural drainage water, tertiary-treated wastewater, fruit quality, date palm cultivars (Khalas, Sheshi and Ruzeiz)

Introduction

The date palm (*Phoenix dactylifera* L.) is one of the most important crop in arid and semi-arid regions of the world, because it's fruits had the essential source in the nutrition pattern of many peoples. Moreover date palm is a major fruit tree in Saudi Arabia. According to the Agricultural Statistical Year Book, (2012), the total production of date fruits was about 986409 tons from 23458299 trees (157074 ha). In this concern more than 400 cultivars are grown in different regions of Saudi Arabia according to the variability of their climatic conditions; however Khalas, Sheshi, and Ruzeiz represent the most important cultivars.

The agricultural sector is the major consumer of water in Saudi Arabia, and it uses two-thirds of the available water resources. The use of treated waste water in agriculture could help to conserve freshwater and fertilizer application. In many parts of the world, treated waste water has long been used for irrigation (Levine and Sanot, 2004). However, waste waters reportedly contain salts, heavy metals, nutrients, pathogens, and pollutants with unknown effects on the ecosystems (Mohammad and Mazahareh, 2003).The unconventional water resources, such as agricultural drainage water (DW), and tertiary-treated wastewater (TTWW) that are applied

Corresponding Author: Shahin M.M., Soil and Water Dept., Fac. of Agric., Al-Azhar Univ., Cairo, Egypt.
E-mail: mshahin58@yahoo.com

individually or in mixtures with groundwater (GW), have been used for long-term soil irrigation in Al-Hassa Oasis (Shahin and Hussein, 2005).

Al Omron *et al.* (2012) found that one of the long-term effects of irrigation with treated sewage effluent in Al-Hassa, Saudi Arabia led to a significant increase in the soil's organic matter content. The suspended, colloidal and dissolved solids present in wastewater contain macro- and micronutrients, which are essential for crop nutrition. However, the nutrients content of the wastewater may exceed the plant needs, and thus pose a potential source for underground water pollution. It may also cause problems related to excessive vegetative growth, delayed or uneven maturity, or reduced quality of the irrigated crops. Calculating the nutrients present in the treated effluent as part of the overall fertilization program of the irrigated crops is necessary.

Al- Busaidi *et al.* (2015) found that the concentration of heavy metals in soils and date palms irrigated by either groundwater or treated wastewater for seven years, were within the international standards. They were significant variations in heavy metal concentrations in the soil at the studied locations. In most of the cases, the concentrations of heavy metals were relatively higher in soils irrigated with treated waste water as compared to the soils irrigated with groundwater. Generally, the difference concentrations of heavy metals in date palm leaves were not significant in plants irrigated with treated waste water or groundwater. While, these differences were significant between the concentrations of heavy metals in date fruits irrigated with different sources of water. The concentrations of some metals (Fe, Zn, and Ni) in date fruits were higher in waste water-irrigated plants; whereas other metals (Cu, Cd, Pb, and B) were higher in ground water treated plants. In all cases the concentrations were within the permissible limits.

The effect of treated sewage water on the vegetative and reproductive growth of date palms was assessed. Leaves and fruits samples were collected from locations irrigated with treated sewage water (TSW), desalinized water, and well water. Samples were analyzed for their calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe), lead (Pb), copper (Cu), and zinc (Zn) contents. The differences of Mg, Fe, and Zn contents of fruits and Na in the leaves were not to be significant. Treated sewage water has significantly increased the Na, K, and Cu, and reduced Ca in leaves and Zn in fruits of date palms. However no significant effect was observed in the content of K, Ca, Mg, and Na in fruits of the same palms. The different concentrations of Ca, Mg, Fe, and Zn in the fruits of the date palms grown along the same TSW line were attributed to variability of the soil native supply of these nutrients. The general trend indicated that fruits contained higher K, Na, and Fe contents, but lower Ca, Mg, Cu, Zn, and Pb contents than the leaves. Furthermore, leaves of date palms irrigated with desalinized and well water contained higher Ca and Zn, but lower K, Mg, Na, Cu, Fe, and Pb than those of palms irrigated with treated sewage water (El Mardi, *et al.* 1998).

The use of treated waste water for irrigating the agriculture in arid- and semiarid regions of the world is expected to free-up and prevent the contamination of good quality water resources for the use in urban and industrial sectors (Abdelrahman *et al.*, 2011). Thus, indiscriminate use of treated waste water for irrigating crops could result in accumulation of total soluble salts including heavy metals in soil. This premise is supported by many reports in literature that the contents of heavy metals (including Fe, Zn, Cu, Mn, Pb and Co) in the soil increased by treated waste water irrigation (Selem *et al.*, 2000). In some studies, an accumulation of heavy metals in the some part of plants has also been reported (Abd-Elfattah *et al.*, 2002).

In trials conducted to determine the effect of salinity on leaf growth, leaf injury, and biomass production in date palm, Al-Abdoulhadi *et al.* (2011) reported that increasing soil salinity levels adversely impacted growth and biomass of date palm, besides causing leaf injury. However, Saudi Arabia's premier date cultivar (Khalas) was the most salt tolerant cultivar tested in the study, as it recorded the best leaf growth, least leaf injury and significantly lowest reduction in biomass upon application of salt treatments. Moreover, the rapid urbanization with high population growth, and increasing need for agricultural production has led to a high demand of using unconventional water resources, such as agricultural drainage water (DW), and tertiary-treated wastewater (TTWW) that are applied individually or in mixtures with groundwater (GW) as an alternative source of freshwater (groundwater) for irrigating crops. However, long-term use of treated waste water for irrigating field crops is expected to cause heavy metals accumulation in soil, and consequently in plant leaves and fruits. In Saudi Arabia, very little information is available concerning the effect of the unconventional water resources on soil and plant. Therefore the current study was conducted to evaluate the effect of different irrigation water qualities: groundwater (GW), groundwater/agricultural drainage water (GW+DW), groundwater/tertiary-treated wastewater (GW+TTWW), and groundwater/agricultural drainage water/tertiary-treated wastewater (GW+DW+TTWW)on macro and micro nutrients. Their effect on some heavy metals contents in leaves and fruits was also taking into consideration, as well as yield and fruit quality of the three date palm cultivars (Khalas, Sheshi and Ruzeiz) at Tamr ; ripening stage.

Material and Methods

Farm selection:

This study was conducted in Al-Hassa Oasis during the 2010 and 2011 seasons. Four different areas that irrigated with four water types of water qualities for long periods more than 15 years were chosen within the area that is served by Al-Hassa Irrigation and Drainage Authority (HIDA). The first area named F7, F3 and P4 it represent the farms that irrigated with GW only. The second area represent the farms that irrigated with GW mixed with DW was named F2. The third area in which the farms were irrigated with TTWW mixed with GW was named P1. The fourth area in which the farms were irrigated with GW mixed with DW and TTWW was named F1. The farms were randomly selected within each area. Each farm contained three date palm varieties: Khalas, Sheshi and Ruzeiz, and the palms had20 years old and in good physical condition. The number of spathes per palm was adjusted to 11/Khalas, 12/Sheshi and 14/Ruzeiz by removing the earliest, latest and smallest spathes.

Experimental design:

The layout of the experimental area was factorial in a completely randomized block design with three replicates (farms). The first factor included four irrigation water qualities (GW, (GW+DW), (GW+TTWW) and (GW+DW+TTWW), whereas the second represented three date palm cultivars (Khalas, Sheshi and Ruzeiz). Within each farm, nine palm trees were selected, and three replicates were produced for each cultivar.

Soil analysis:

The physical and chemical properties, macro- and micro-nutrients, as well as concentration of certain heavy metals of the soils were measured. Four representative soil samples were collected from each farm, using an auger at three depths: (zero-30, 30-60, and 60-90 cm), and each of 4 samples representing the same depth were mixed together to make a composite sample. The sample location was recorded using a Global Positioning System (GPSmap 276C , Garmin International, Inc. 1200 E. 151st St. Olathe, KS 66062-3426, USA). All of the collected soil samples were air dried, crushed and sieved through a 2-mm sieve, and stored in plastic bottles before analysis. The soil organic matter content was determined according to Walkley and Black using the rapid titration method Page *et al*. (1982). Saturated soil paste extract for chemical analysis were prepared according to the method of Page *et al*. (1982). The electrical conductivity (EC) and the total dissolved salts (TDS) was estimated in the soil extraction using a conductivity meter (temperature compensating Hach EC meter), which measured the cell-expressed conductivity in dS/m according to the method of Rhoades (1992). The soil pH was measured in the soil paste (suspension) according to the method of Datta *et al*. (2001) using a pH meter (Hack 108). The soluble CO_3^{2-} and HCO_3^- were determined in the soil extract by titration with HCl according to the method of Nelson (1982). The soluble chloride in the soil extract was determined according to the method of Moore (Rhoades, 1992). The soluble sulfate in the soil extract was calculated as the difference between the concentrations of total dissolved cations and anion concentration in mEq/L. The soluble calcium and magnesium in the soil extract were determined according to the method of Rhoades (1992). The soluble sodium and potassium in the soil extract were determined in the soil paste extract using a flame photometer (BWB-XP) according to the method of Jackson (1973). The exchangeable sodium percentage (ESP) was determined according to the methods that are outlined in Carter (1993) and Rhoades (1992). The available N was determined according to method of Keeney and Nelson (1982). The available phosphorus in the soil extract was determined according to the method of Olsen and Sommers (1982). The available potassium was determined according to the method of Richard (1972), and measured using a flame photometer (BWB-XP). The micronutrients(Fe, Mn, Cu and Zn) and heavy metals (Co, Cd, Pb, As, and Ni) in the soil were extracted using the chelating agent diethylenetetraminepenta acetic acid-triethanolamine (DTPA-TEA) at pH 7.3 according to the method of Lindsay and Norvell (1978),and measured using the atomic absorption spectrophotometer (AA-6300 Shimadzu Corporation, Japan).

Water analysis:

Three replicates of each water source were collected every three months, and filtrated. The filtrate was analyzed for the contents of Fe, Mn, Cu, Zn, Cd, Co, Pb, As and Ni using the atomic absorption spectrophotometer (AA-6300). The quality of the irrigation water was determined according to Ayers and Westcot (1994), and FAO, (1976). The total salinity of irrigation water was expressed in terms of electrical conductivity (EC_{iw}, dS/m^{-1}). The concentrations of Ca^{2+}, Mg^{2+}, Na^+, K^+, CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-} ions were measured; and the hazard parameters were calculated as follows: sodium was expressed as the sodium adsorption ratio (SAR) or soluble sodium percentage (SSP, %); the magnesium hazard (SMgP) was expressed as the soluble magnesium percentage (SMgP, %); the bicarbonate hazard was expressed as the value of residual sodium carbonate (RSC, me/L); and the ion concentration was expressed in mEq/L.

Plant sampling:

The palms of three cultivars were selected i.e. Khalas, Sheshi and Ruzeiz that had 20 years old and in good physical condition. The number of spathes per palm was adjusted to 11/Khalas, 12/Sheshi and 14/Ruzeiz by removing excess earliest, latest and small ones. For each farm three date palms for each cultivar were chosen randomly to collect a composite leaf sample from each date palm using five pinnate from the middle of the third leaf (from top) in all directions, i.e. 20 pinnate per date palm. Leaf samples were washed with tap water, distilled water, air-dried, oven dried at 65C° for 72 hrs, and then ground in a stainless steel mill and the powder stored for chemical analysis as the study required. The ground material (plant powder) was digested with concentrated Sulphuric acid + Perochloric acid according to the method of Wolf (1982). In the digest, Fe, Mn, Cu, Zn, Cd, Co, Pb , As and Ni were measured using Atomic Absorption Spectrophotometer (AAS) Model AA-6300 Shimadzu Corporation, Japan.

Yield and Fruit quality:

The date fruits at the ripening stage were harvested during the 2010 and 2011 summer seasons. The bunches per palm (11/Khalas, 12/Sheshi and 14/Ruzeiz) were weighed (kg), and the fruit yield was estimated. Random collection of 30 fruits from each replicate (farm) was performed, and the following physical measurements were conducted: the fruit weight (g), pulp weight (g), and seed weight (g) were measured using a sensitive balance (204 Mettler, Toledo, Switzerland); the length and width of both the date fruits and stones were measured using an ABSOLUTE Digimatic digital electronic vernier caliper (CD-15CW, Mitutoyo Corporation, Japan) with 0.00-mm readability; the length was defined as the longest dimension in the direction that was parallel to the fruit stem, whereas the major diameter was the maximum dimension that was perpendicular to the stem; the moisture content (%), total soluble solids (TSS), and total reducing and non-reducing sugars were determined according to the Association of Analytical Communities (AOAC) standard methods of analysis (AOAC, 2000).

Statistical analysis

The data were statistically analysed using the analysis of variance (ANOVA) according to Gomez and Gomez (1984). The differences among treatment means were compared using the least significant differences (LSD) test using the statistical analysis systems software (SAS, 2001).

Results and Discussion

Water chemical analysis:

Data presented in Table (1) expressed as the average values of chemical composition of different irrigation water qualities, indicated that the values of EC were (2.81 dS m^{-1}), (5.04 dSm^{-1}), (3.15 dS m^{-1}) and (4.21 dS m^{-1}) for (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW) water samples respectively; whereas the corresponding values of TDS were 1798.4, 3225.6, 2016.0 and 2694.4 mg/L for (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW), respectively. The data also illustrate that the highest value of EC was recorded in case of (GW+DW) followed by (GW+DW+TTWW) and (GW + TTWW) while the lowest value of EC was recorded with (GW).

Table (1): Chemical composition of different irrigation water qualities used for irrigation of Al- Hassaa soil.

Characteristics	Irrigation Water				LSD at 5%
	GW	GW+DW	GW+TTWW	GW+DW+TTWW	
EC (dS/m)	2.81 d	5.04 a	3.15 c	4.21 b	0.002
TDS (mg/L)	1798.4 d	3225.6 a	2016.0 c	2694.4 b	3.700
pH	7.63 c	7.80 a	7.55 d	7.77 b	0.002
Soluble Cations, m mole/L					
Ca^{2+}	7.94 d	13.26 a	9.40 c	10.44 b	0.004
Mg^{2+}	4.36 d	7.58 a	4.90 c	6.90 b	0.004
Na^{+}	14.9 d	28.42 a	16.26 c	23.92 b	0.004
K^{+}	0.90 c	1.14 a	0.94 b	0.84 d	0.004
Soluble Anions, m mole/L					
CO_3^{2-}	-	-	-	-	-
HCO_3^{-}	4.46 c	8.84 a	3.62 d	5.70 b	0.004
Cl^{-}	10.00 d	17.34 c	20.32 b	22.34 a	0.120
SO_4^{2-}	13.64 c	24.22 a	7.56 d	14.06 b	0.004
NO^{-}_3 , mg/L	5.23 d	10.21 c	11.34 b	13.53 a	0.240
Micronutrients, mg/L					
Cu	0.012 b	0.016 ab	0.019 c	0.026 a	0.060
Mn	0.017 d	0.022 b	0.027 c	0.032a	0.002
Fe	0.072 d	0.085 c	0.095 b	0.099 a	0.002
Zn	0.045 d	0.076 c	0.085 b	0.090 a	0.110
B	0. 35 b	0. 48 a	0. 26 b	0. 57 a	0.110

The value of eachcharacter is the average of 24 water samples for each irrigation water quality during two seasons (2010&2011) noting that Gw= (ground water); GW+DW= (ground water + agricultural drainage water); GW+TTWW= (ground water + tertiary treated wastewater); GW+DW+TTWW= (ground water + agricultural drainage water + tertiary treated wastewater).

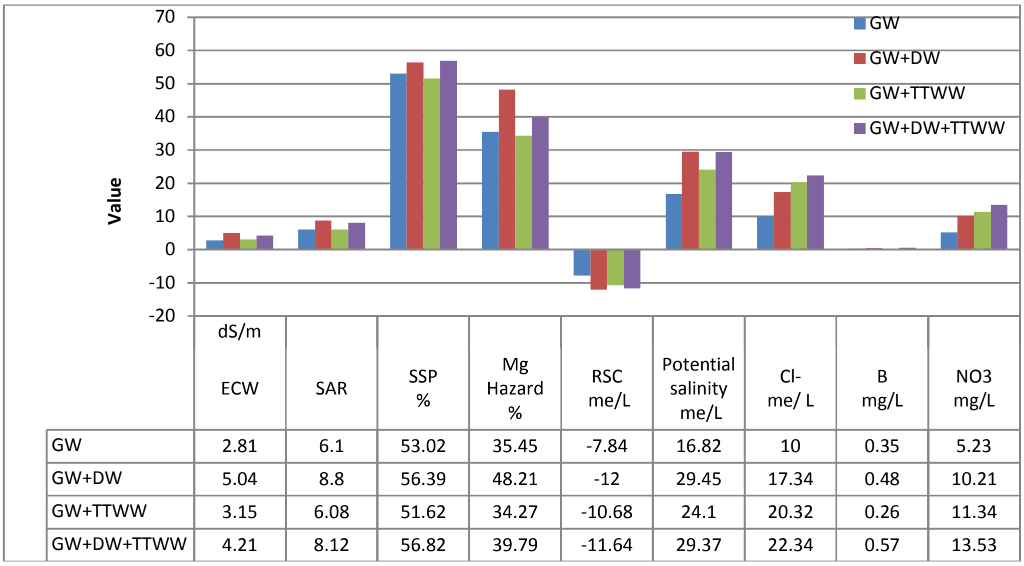
The parameters of water quality for all investigated water types are presented in Table (2), and shown in Figure (1). From these data, it appears that all types of irrigation water, has the EC_{iw} values in the range of 2.81 to 5.04 dS/m. The critical level of EC_{iw} in which cause severe salinity problems is 3 dS/m as reported by FAO (1976). The values of EC_{iw} of (GW) were less than the critical limit, and there are no problems in using for irrigation water followed by (GW + TTWW). Where the EC_{iw} values of (GW+ DW) and (GW+DW+TTWW) are more than the critical level; this may cause severe salinity problems due to high level of salinity.

It is seen that the high level of salinity in irrigation water (expressed as the total amount of salt dissolved in water) reduces water availability to the crop (because of osmotic pressure), and causes yield reduction. The most common parameters used for determining the irrigation water quality, in relation with its salinity, are EC and TDS

Table 2: Average values of parameters of different irrigation water quality.

Irrigation water	EC_W dS/m	SAR	SAR adj.	SSP %	Mg Hazard%	RSC me/L	Potential salinity me/L	Cl^- me/L	B mg/L	NO^-_3 mg/L
GW	2.81 d	6.01 c	11.05 c	53.02 c	35.45 c	-7.84 a	16.82 c	10.00 d	0.35 d	5.23 d
GW+DW	5.04 a	8.80 a	18.23 a	56.39 a	38.21 b	-12.00 b	29.45 a	17.34 c	0.48 b	10.21 c
GW+TTWW	3.15 c	6.08 d	10.30 d	51.62 d	34.27 d	-10.68 a	24.10 b	20.32 b	0.26 c	11.34 b
GW+DW+TTWW	4.21 b	8.12 b	16.96 b	56.82 b	39.79 a	-11.64 b	29.37 a	22.34 a	0.57 a	13.53 a
LSD at 5%	0.089	0.109	0.109	0.334	0.126	1.151	0.063	0.063	0.002	0.363

Means in each column followed by the same letter(s) did not differ at < 0.50 according to Duncan's multiple-range test.
The value of each parameter is an average of 24 water samples for each irrigation water quality during two seasons (2010&2011).



	dS/m ECW	SAR	SSP %	Mg Hazard %	RSC me/L	Potential salinity me/L	Cl- me/ L	B mg/L	NO3 mg/L
GW	2.81	6.1	53.02	35.45	-7.84	16.82	10	0.35	5.23
GW+DW	5.04	8.8	56.39	48.21	-12	29.45	17.34	0.48	10.21
GW+TTWW	3.15	6.08	51.62	34.27	-10.68	24.1	20.32	0.26	11.34
GW+DW+TTWW	4.21	8.12	56.82	39.79	-11.64	29.37	22.34	0.57	13.53

Fig. 1: The Average values parameters of different irrigation water quality.

Chemical properties of soil irrigated by different irrigation water qualities:

Data in Table (3) illustrates the effect of different irrigation water qualities on the chemical properties of soils (twelve sites) cultivated with palm cultivars. The data revealed that soil pH, electrical conductivity (EC dS/m) and organic matter content (g/kg) are affected by different irrigation water qualities for different soil depths: 0-30 cm, 30-60 cm and 60-90 cm. The average values of EC reached up to: 2.74, 3.16, 2.57 and 3.52 dS/m at 0-30 cm depth, while the corresponding value of EC (dS/m) at the depth 30-60 cm were 2.93, 4.06, 2.77 and 3.67dS/m, and the values of EC (dS/m) at depth 60-90 cm were: 3.02, 4.29, 2.83 and 3.87dS/m for the soils irrigated by GW, (GW+DW), (GW+TTWW) and (GW+ DW + TTWW) respectively. Also the data reveal that there is a marked increase in soil salinity with depth in all soil samples irrigated by different irrigation water qualities. This was true for all qualities of irrigation water.

The effect of different irrigation water qualities on soil macronutrient contents:

The data in Table (4) illustrates the effect of different irrigation water qualities on the macronutrients contents (mg/kg soil) in the investigated soils that cultivated with date palm cultivars. The results indicated that the use of (GW+TTWW), (GW+ DW +TTWW) and (GW+DW) for irrigation increased the content of the available (NPK) in the soils as compared to the content in soil irrigated by ground water (GW). The values reached to 32.96, 44.56, 58.68 and 51.39 mg/kg soil for nitrogen content at 0-30 cm depth for the soils irrigated by GW, (GW+DW), (GW+TTWW) and (GW+ DW +TTWW), respectively. The relative increase of nitrogen content in soils irrigated with different irrigation water qualities compared to the soil irrigated by ground water at soil profile from (0-30cmdepth) were as follows: 35.19%, 78.68% and 55.92% for (GW+DW), (GW+TTWW) and (GW+ DW +TTWW) respectively. Nitrogen content of treated wastewater ranges from 20 to 60 mg / L. Knowledge of the N concentration in the treated wastewater and the proper management of the load of N P K are essential to overcome problems associated with eventual high N concentration (FAO 2003).

Table 3: Chemical analysis of investigated soil irrigated by different irrigation water qualities.

Chemical Properties	Depth cm	Irrigation Water Quality				LSD at 5%
		GW	GW+DW	GW+TTWW	GW+DW+TTWW	
E.C (dS /m)	00-30	2.74 b	3.16 ab	2.57 b	3.52 a	0.582
	30–60	2.93 c	4.06 a	2.77 d	3.67 b	0.002
	60-90	3.02 c	4.29 a	2.83 d	3.87 b	0.002
pH	00-30	7.63 c	7.67 b	7.61 d	7.70 a	0.002
	30–60	7.45 d	7.60 a	7.54 b	7.51 c	0.002
	60-90	7.33 d	7.55 a	7.50 b	7.40 c	0.002
O.M. g kg	00-30	6.50 d	7.60 b	8.80 a	7.40 c	0.002
	30–60	5.40 d	5.70 b	7.30 a	6.40 c	0.002
	60-90	3.50 d	3.90 b	5.20 a	6.00 c	0.002
Ca^{++}mmole/L	00-30	9.02 c	11.14 b	8.70 d	11.76 a	0.004
	30–60	9.30 d	12.06 a	9.34 c	11.72 b	0.004
	60-90	9.60 d	14.34 a	9.78 c	14.08 b	0.004
Mg^{++}mmole/L	00-30	1.34 c	3.22 a	1.60 b	1.72 c	0.004
	30–60	1.46 d	2.98 a	1.76 b	1.64 b	0.004
	60-90	1.60 d	3.86 a	1.84 c	2.00 b	0.004
Na^{+}mmole/L	00-30	16.46 c	22.24 a	15.12 d	21.02 b	0.004
	30–60	18.54 c	24.90 a	16.70 d	22.46 b	0.004
	60-90	18.56 c	34.74 a	18.54 d	28.22 a	0.004
K^{+}mmole/L	00-30	0.54 d	0.74 a	0.58 c	0.70 a	0.004
	30–60	0.58 d	0.70 b	0.64 c	0.74 b	0.004
	60-90	0.72 c	0.82 b	0.70 d	0.86 b	0.004
HCO_3^{-}mmole/L	00-30	7.72 d	12.52 a	8.64 c	10.40 b	0.004
	30–60	7.16 d	13.20 a	9.90 c	11.30 b	0.004
	60-90	6.62 d	15.90 a	10.36 c	11.90 b	0.004
CLmmole/L	00-30	10.42 d	23.18 b	13.54 c	23.46 a	0.004
	30–60	10.96 d	25.10 a	16.52 c	22.70 b	0.004
	60-90	13.72 d	31.86 a	19.20 c	24.40 b	0.004
SO_4^{-2}mmole/L	00-30	9.24 a	1.70 c	3.74 b	1.46 d	0.004
	30–60	10.22 a	2.34 c	2.14 d	2.60 b	0.004
	60-90	8.16 b	6.08 c	0.82 d	8.84 a	0.004
SAR	00-30	7.23 d	8.30 a	6.66 c	8.10 b	0.089
	30–60	7.95 d	9.08 a	7.06 c	8.69 b	0.126
	60-90	7.84 d	11.52 c	7.69 c	9.95 a	0.089
Adj. SAR	00-30	11.75 b	13.50 a	11.24 b	13.47 a	0.712
	30–60	13.01 c	14.67 a	11.51 d	14.09 b	0.063
	60-90	12.80 c	18.67 a	12.52 d	16.18 b	0.063
ESP	00-30	5.70 d	11.80 a	6.21 c	10.27 b	0.089
	30–60	6.04 d	12.36 a	6.47 c	10.75 b	0.089
	60-90	5.82 d	13.28 a	8.48 c	11.55 b	0.126

Means in each row followed by the same letter(s) did not differ at < 0.50 according to Duncan's multiple-range test.
The value of each property is the average of 6 soil samples for each depth collected at two seasons (2010&2011).

The results indicadted that phosphorus content values amounted to 12.00, 21.06, 24.52 and 21.29 mg/kg soil at 0-30cm depth for the soils irrigated by GW, (GW+DW), (GW+TTWW) and (GW+ DW +TTWW) respectivaly.These results are in agreement with those reported by Mohammad and Mazahreh, (2003)who found that extractable phosphorus was higher in soils irrigated with wastewater than in soil irrigated with fresh water or rainfall water.

The K content in soil irrigated by diffrent water qualities at 0- 30 cm was14.05, 18.45, 26.71 and 22.23 mg/kg soil for GW, (GW+DW), (GW+TTWW) and (GW+ DW +TTWW) respectivaly. From this data it is clear that the tertiary treated wastewater irrigation has significantly increased the soil NPK contents compared with other different irrigation water qualities. This increase was highest in the surface soil (0–30cm depth) for the long period of irrigation by tertiary treated wastewater. This is attributed to the original high contents of these nutrients in the tertiary treated wastewater.

Table 4: Macronutrients content (mg/kg) in the investigated soil (farms) irrigated with different irrigation water qualities.

Chemical Properties	Depth cm	Irrigation Water Quality				LSD at 5%
		GW	GW+DW	GW+TTWW	GW+DW+TTWW	
N (meg/kg soil)	00-30	32.96 d	44.56 c	58.68 a	51.39 b	5.56
	30–60	21.20 d	35.52 c	39.43 a	39.18 b	0.002
	60-90	17.44 d	21.95 c	28.25 a	23.20 b	0.002
P (meg/kg soil)	00-30	12.00 d	21.06 c	24.52 a	21.29 b	0.002
	30–60	5.85 a	0.88 b	0.18 b	0.72 b	4.61
	60-90	6.81 d	11.26 c	13.45 a	12.93 b	0.002
K (meg/kg soil)	00-30	14.05 d	18.54 c	26.71 a	22.23 b	0.002
	30–60	11.15 d	14.78 c	17.90 a	17.03 b	0.002
	60-90	9.57 d	10.95 c	13.83 a	12.41 b	0.002

These results are in agreement with those obtained by Nyamangara and Mzezewa (2000). They found that the concentration of K decreased with depth. This increase of NPK in the soil surface and decrease in their contents with the depth were attributed to the vertical movement of irrigation water with depth. In other words this may be due to the role of permeabity of irrigation water through the soil.

Concering the variation in the chemical composition of the treated wastewater, reuse management should account for the N, P, and K content prior to determination of the rate of wastewater addition or fertilization program application.

Phosphorus in the treated wastewater varies from 6 to 15 mg/l (15-35 mg/ L P_2O_5) unless removal is accomplished during treatment. Evaluation of P in the treated wastewater should be made in conjunction with soil testing for fertilization planning. In this concern potassium concentration in the treated wastewater is not known to cause adverse effects on plants or the environment. It is essential macronutrient and positively affects the soil fertility, crop yield and quality. The range of K concentration in treated wastewater is 10 to 30 mg/l (12-36 mg/L K_2O). This amount must be taken into consideration in formulating the fertilization programmer according to crop needs (FAO 2003).

For N, P, and K in the soil irrigated by tertiary treated wastewater or agricultural drainage water in a saline habitat, the presence of salinity alters the nutritional balance of plants, resulting in high ratios of Na^+/K^+, Na^+/Ca^{2+}, Na^+/Mg^{2+} and Cl^-/NO_3^- (Grattan and Grieve, 1992), which may cause reduction in growth. Major saline ions can affect nutrient uptake through competitive interactions, or by affecting the ion selectivity of membranes. Examples of these effects include Na^+ induced Ca^{2+} or K^+ deficiencies, or both, and Ca^{2+} induced Mg^{2+} deficiencies (Grattan and Grieve, 1992). There are several studies showing the effects of salinity on macro and micronutrients (Nieves *et al*., 1990, Zekri, 1993 and Abdel-Nasser *et al*., 2000).

Effect of different irrigation water qualities on the content of some nutrients and heavy metals in the Leaf of different date palm cultivars

Crops can be characterized by typical chemical composition of growing or developed tissues. Chemical analysis of plant parts is often used for diagnostic purpose in determining fertilizer needs. Poor fertility level, excessive concentration of available nutrients, or high salinity in the root zone is reflected in lower or higher concentrations of certain elements in plant tissues in comparison with the optimum range (Feigin, 1985).

Data in Table (5) illustrates the effect of different irrigation water qualities on the content of some nutrients and heavy metal in the leaf of different date palm cultivars (Khalas, Shishi and Ruzeiz (mg/kg). The results indicated that (GW+ DW+TTWW), (GW+TTWW) and (GW+DW) increased the micronutrients, (Fe, Mn, Cu and Zn) contents in leaves of date palm cultivars, in this concern an increase in heavy metals, (Co, Cd, Pb, As and Ni) contents in the leaves was recorded as compared to its content in leaves of date palm cultivars grown in the soil irrigated by groundwater only.

Table 5: Effect of different irrigation water qualities on leaves mineral composition (mg/kg dry matter) of date palm in the soil (farms) under the study.

Treatments \ Characters		Cu	Mn	Fe	Zn	Co	Cd	Pb	As	Ni
A: Water irrigation qualities:										
GW		3.79 d	4.83 d	76.91 d	4.27 d	0.27 d	0.24 d	0.49 d	0.36 d	0.18 d
GW+DW		6.03 a	10.4 b	110.5 b	7.10 b	0.46 b	0.38 b	0.63 b	0.52 b	0.22 b
GW+TTWW		4.97 c	7.85 c	92.63 c	5.39 c	0.35 c	0.30 c	0.57 c	0.45 c	0.22 c
GW+DW+TTWW		5.95 b	11.6 a	119.6 a	8.13 a	0.50 a	0.44 a	0.68 a	0.57 a	0.29 a
LSD at 5%		0.0009	0.0009	1.37	0.031	0.0008	0.0009	0.001	0.0009	0.0009
B: Cultivars										
Khalas		4.99 b	9.12 b	96.92 b	6.57 b	0.39 b	0.32 b	0.61 b	0.45 b	0.23 b
Sheshi		4.12 c	6.30 c	77.08 c	5.01 c	0.32 c	0.26 c	0.43 c	0.39 c	0.20 c
Ruzeiz		6.45 a	10.6 a	125.7 a	7.09 a	0.48 a	0.44 a	0.73 a	0.59 a	0.26 a
LSD at 5%		0.0008	0.0008	1.18	0.027	0.0008	0.0008	0.0008	0.0008	0.0008
C: Interaction AxB										
GW	Khalas	3.27 k	5.18 k	78.61 h	4.32 i	0.28 k	0.21 k	0.5 i	0.34 k	0.19 i
	Sheshi	3.04 l	3.42 l	56.21 j	3.54 j	0.22 l	0.17 l	0.34 l	0.30 l	0.15 j
	Ruzeiz	5.05 f	5.89 i	95.92 e	4.94 h	0.32 i	0.34 g	0.64 f	0.45 g	0.21 g
GW+ DW	Khalas	5.81 e	10.7 d	102.3 d	7.53 d	0.47 d	0.38 e	0.64 e	0.48 e	0.22 f
	Sheshi	4.83 g	7.51 h	87.56 g	5.84 g	0.38 f	0.31 h	0.46 j	0.41 i	0.20 h
	Ruzeiz	7.45 a	12.9 b	141.6 b	7.94 c	0.54 b	0.47 b	0.77 b	0.66 b	0.25 c
GW + TTWW	Khalas	4.56 h	8.75 f	92.65 f	5.94 f	0.34 h	0.27 i	0.59 g	0.43 h	0.21 g
	Sheshi	4.15 j	5.60 j	70.80 i	4.30 i	0.31 j	0.23 j	0.41 k	0.36 j	0.20 h
	Ruzeiz	6.23 d	9.20 e	114.4 c	5.93 f	0.41 e	0.41 d	0.71 c	0.55 c	0.24 e
GW + DW + TTWW	Khalas	6.32 c	11.9 c	114.4 c	8.48 b	0.48 c	0.43 c	0.71 d	0.54 d	0.29 b
	Sheshi	4.47 i	8.68 g	93.75 ef	6.37 e	0.35 g	0.35 f	0.52 h	0.47 f	0.24 d
	Ruzeiz	7.06 b	14.3 a	151.0 a	9.54 a	0.66 a	0.53 a	0.81 a	0.71 a	0.34 a
LSD at 5%		0.0016	0.0016	2.37	0.054	0.0016	0.0017	0.0017	0.0017	0.0017

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

The results also showed that (GW+ DW+TTWW) irrigation water has the highest values of leaves mineral composition that reached up to 11.60 mg/kg for Mn, 119.6 mg/kg for Fe, 8.13 mg/kg for Zn, 0.50 mg/kg for Co, 0.44 mg/kg for Cd, 0.68 mg/kg for Pb, 0.57 mg/kg for As and 0.29 mg/kg for Ni. The differences between the different irrigation water qualities in their effect on the leaves mineral composition of the date palm cultivars (Khalas, Shishi and Ruzeiz) were significant.

Results also showed that the contents ofthe micronutrients Fe, Mn, Cu , Zn as well as heavy metals Co, Cd, Pb, As and Ni in the leaves of date palm cultivars are higher in the leaves of Ruzeiz cultivar as compared with their contents in Khalas and Shishi cultivars under different irrigation water qualities. The average values of the leaves mineral composition for Ruzeiz cultivar reached to 6.45 mg/kg for Cu, 10.6 mg/kg for Mn, 125.7 mg/kg for Fe, 7.09 mg/kg for Zn, 0.48 mg/kg for Co, 0.44 mg/kg for Cd, 0.73 mg/kg for Pb, 0.59 mg/kg for As, and 0.26 mg/kg for Ni; attaining the highest values as compared to the leaves mineral composition for Khalas and Shishi cultivars under different irrigation water qualities.

As regard to the nutrients criteria, the concentrations of Mn in date palm cultivars are within the normal range (15-100 ppm) (Hausenbuiller, 1985). Whereas the levels of Zn in the date palm cultivars were less than the general toxic limit for plants given by Leeper (1972) of 500 mg/kg. The values of Cu concentration in the date palm cultivars were within the normal range found in plants (5-15ppm) (Hausenbuiller, 1985). The concentrations of Fe in the plants of date palm cultivars Khalas, Shishi and Ruzeiz were within the normal range found in plants (30-150 ppm), but generally these excess concentrations are not toxic to plants (Hausenbuiller, 1985).

Hussein (1991) reported that drainage irrigation water significantly increased Fe, Mn, Cu and Zn in corn, sugar beet and cotton plants. Shahin and Hussein (2005) reported the effect of different types of irrigation water on Cd content in cucumber, lettuce and tomato plants in the following order (GW+DW+TTWW) > (GW+TTWW) > (GW+DW) > (GW). These results are in contrast with those obtained by Abdel-Nasser *et al.* (2000), who found that the leaf micronutrient contents (Fe, Mn, Cu, Zn and B) in olive plants significantly decreased by increasing the salinity of irrigation water.

The use of either the tertiary treated wastewater or the agricultural drainage water mixed with the groundwater as irrigation water resources were studied by Mohammad and Mazahreh (2003). They are recognized to have direct effect on soil chemical properties. It affects the supply of mineral macro and micro nutrients for plant growth. Other researchers found that tertiary treated wastewater irrigations increased soil NPK, while the heavy metal levels tended to generally increase in soil with increasing the number of years of irrigation (Munir *et al*., (2007).

Effect of different irrigation water qualities on the content of some nutrients and heavy metals in Fruits mineral of different date palm cultivars:

The data presented in Tables (6 and 6a) shows the effect of different irrigation water qualities on the content of some nutrients and heavy metals in Fruits of different date palm cultivars. The results indicated that (GW+ DW+TTWW) gave the highest increase of macronutrients content in the fruits of date palm which reached to 2.72 %, 0.40 % and 1.64% for N, P and K respectively. Followed by (GW+TTWW) where the respective values of N, P and K were 2.72%, 0.39% and 1.42%, while the corresponding values for (GW+DW) for N, P and K were 2.24%, 0.24% and 1.28 % respectively. In this concern the lowest values of macronutrients content in the fruits of different date palm cultivars were recorded with (GW), it reached to 1.78% for N, 0.15% for P, and 1.10% for K.

Also the contents of the micronutrients (Fe, Mn, Cu and Zn) and the heavy metals (Co, Cd, Pb, As and Ni) in the fruits of date palm cultivars attained highest values with (GW+ DW+TTWW) followed by (GW+TTWW) and (GW+DW) as compared to their content in fruits of date palm cultivars grown in the soil irrigated by ground water (GW). There is a significant difference between the different irrigation water qualities regarding their effect on fruits mineral content of date palm cultivars Khalas, Shishi and Ruzeiz; all concentrations were within the permissible limits.

These results are in agreement with those obtained by (Elgala *et al*., 2003), who found that Fe and Cu concentrations in clover tissues grown in Elgabal Elasfar soil that irrigated with treated wastewater were more than their concentrations in clover tissues grown in Elgabal Elasfar soil, that irrigated by fresh water.

The data in Tables (6, 6a) shows that the concentrations of macronutrients (N, P, K) and the micronutrients (Fe, Mn, Cu , Zn)as well as heavy metals (Co, Cd, Pb, As and Ni) in the fruit of date palm cultivars are higher in the fruits of Ruzeiz cultivar as compared with their contents in either Khalas or Shishi cultivars under different irrigation water qualities.

The average values of N, P and K content in the fruits of Ruzeiz cultivar reached to 2.46%, 0.32% and 1.44% respectively. While the micronutrients values (mg/kg) in fruits of Ruzeiz cultivar reached to 4.04 mg/kg 3.75 mg/kg 11.15 mg/kg, 3.39 mg/kg for Cu, Mn, Fe, and Zn respectively. While the heavy metals content in the fruit of Ruzeiz cultivar were 0.30, 1.61, 1.37, 0.38, and 0.34 mg/kg for Co, Cd, Pb, As and Ni respectively, attaining the highest values as compared to their contents in fruits of Khalas and Shishi cultivars under the same irrigation water quality, as well as when compared under different irrigation water qualities.

Table 6: Effect of different irrigation water quality on fruit mineral composition (mg/kg dry matter) of different date palm cultivars grownin soil (farms) under investigation.

Treatments		N%	P%	K%	Cu mg/kg	Mn mg/kg	Fe mg/kg
A: Water irrigation qualities:							
GW		1.78 c	0.15 d	1.10 d	3.08 d	2.53 d	7.98 d
GW+DW		2.24 b	0.24 c	1.28 c	3.91 c	3.18 c	10.08 c
GW+TTWW		2.72 a	0.34 b	1.42 b	4.48 b	3.56 b	10.85 b
GW+DW+TTWW		2.72 a	0.40 a	1.64 a	4.73 a	4.02 a	11.62 a
LSD at 5%		0.03	0.001	0.001	0.001	0.17	0.03
B: Cultivars							
Khalas		2.35 b	0.28 b	1.35 b	4.17 b	3.30 b	10.66 b
Sheshi		2.27 c	0.24 c	1.28 c	3.58 c	2.92 c	8.59 c
Ruzeiz		2.46 a	0.32 a	1.44 a	4.04 a	3.75 a	11.15 a
LSD at 5%		0.03	0.001	0.001	0.001	0.14	0.027
C: Interaction AxB							
GW	Khalas	1.76 h	0.16 j	1.10 k	3.15 a	2.65 f	8.47 j
	Sheshi	1.70 i	0.12 k	1.05 l	2.64 a	2.11 g	6.24 l
	Ruzeiz	1.88 g	0.17 i	1.15 j	3.46 a	2.84 ef	9.21 i
GW+ DW	Khalas	2.23 e	0.23 g	1.28 h	3.99 a	3.25 cd	10.75 f
	Sheshi	3.11 f	0.19 h	1.18 i	3.60 a	2.97 de	8.06 k
	Ruzeiz	2.38 d	0.29 f	1.37 f	1.18 a	3.34 c	11.44 d
GW + TTWW	Khalas	2.71 b	0.36 d	1.42 e	4.60 a	3.38 c	11.07 e
	Sheshi	2.64 c	0.30 e	1.34 g	3.96 a	3.16 cd	9.77 h
	Ruzeiz	2.79 a	0.37 c	1.51 d	4.86 a	4.14 b	11.72 c
GW + DW + TTWW	Khalas	2.72 b	0.39 b	1.61 b	4.95 a	3.93 b	12.34 a
	Sheshi	2.65 c	0.36 d	1.57 c	4.13 a	3.43 c	10.29 g
	Ruzeiz	2.79 a	0.45 a	1.74 a	5.12 a	4.70 a	12.22 b
LSD at 5%		0.05	0.002	0.002	NS	0.29	0.05

Within each column, means with the same letter are not significantly different (p ≤ 0.05).

Table 6-a: Effect of different irrigation water quality on fruit mineral composition (mg/kg dry matter) of different date palm cultivars grown in soil (farms) under investigation.

Treatments		Zn	Co	Cd	Pb	As	Ni mg/kg
A: Water irrigation qualities:							
GW		2.53 d	0.17 d	0.57 d	0.31 d	0.16 d	0.10 d
GW+DW		2.83 c	0.22 c	1.20 c	1.10 c	0.25 c	0.19 c
GW+TTWW		3.11 b	0.29 b	1.57 b	1.53 b	0.37 b	0.36 b
GW+DW+TTWW		3.37 a	0.34 a	1.91 a	1.73 a	0.47 a	0.46 a
LSD at 5%		0.16	0.001	0.03	0.03	0.03	0.001
B: Cultivars							
Khalas		2.86 b	0.26 b	1.36 b	1.21 b	0.31 b	0.25 b
Sheshi		2.64 c	0.21 c	0.96 c	0.93 c	0.25 c	0.24 c
Ruzeiz		3.39 a	0.30 a	1.61 a	1.37 a	0.38 a	0.34 a
LSD at 5%		0.14	0.001	0.027	0.027	0.027	0.001
C: Interaction AxB							
GW	Khalas	2.69 ef	0.17 k	0.54 j	0.30 i	0.16 f	0.10 k
	Sheshi	1.95 g	0.13 l	0.39 k	0.26 i	0.10 g	0.06 l
	Ruzeiz	2.96 cde	0.20 i	0.80 i	0.37 h	0.21 ef	0.15 j
GW+ DW	Khalas	2.60 f	0.24 f	1.16 g	1.08 f	0.23 e	0.17 i
	Sheshi	2.72 ef	0.19 j	0.94 h	0.93 g	0.19 ef	0.19 h
	Ruzeiz	3.15 c	0.22 h	1.49 e	1.30 d	0.32 d	0.23 g
GW + TTWW	Khalas	2.95 cde	0.30 d	1.70 d	1.58 c	0.38 c	0.32 f
	Sheshi	2.83 def	0.23 g	1.14 g	1.16 e	0.29 d	0.33 e
	Ruzeiz	3.56 b	0.35 b	1.85 c	1.86 b	0.45 b	0.42 b
GW + DW + TTWW	Khalas	3.19 c	0.32 c	2.03 b	1.87 b	0.45 b	0.41 c
	Sheshi	3.05 cd	0.28 e	1.39 f	1.35 d	0.42 bc	0.39 d
	Ruzeiz	3.87 a	0.42 a	2.29 a	1.97 a	0.55 a	0.57 a
LSD at 5%		0.28	0.002	0.05	0.05	0.05	0.002

Within each column, means with the same letter are not significantly different (p ≤ 0.05)

There is a significant difference between the different irrigation water qualities in their effect on the fruits mineral content in different date palm cultivars (Khalas, Shishi and Ruzeiz). The results revealed that macro and micronutrients contents in the fruits were increased with reuse of (GW+DW+TTWW), (GW+TTWW) and/or (GW+DW) in irrigation purposes, this might be due to the chemical composition of (GW+DW+TTWW), (GW+TTWW) and (GW+DW) and its effect on the available amount of macronutrients (N, P and K) as well as micronutrients (Fe, Mn, Cu , Zn) giving a high content in the irrigated soil as compared with their content in the soil irrigated by ground water. These results are in agreement with those obtained by Munir *et al.* (2007), who reported that the reuse of wastewater in agriculture focuses mainly on its short-term effect on plant growth and development with little attention to the changes induced in the soil fertility and chemistry parameters.

Also their study evaluated the impact of long-term land application of wastewater on soil fertility parameters and possible accumulation of heavy metals in the soil-plant system. The influence of salinity on the micronutrient concentration in plants is highly variable (Grattan and Grieve, 1992). In palm trees, the specific absorption and utilization rates of all micronutrients were reduced by salinity, indicating that the reduction in growth caused by water salinity could be associated with the disturbed absorption of these elements, which are all directly or indirectly involved in photosynthesis (Marschner, 1995).

The concentrations of both the micronutrient and the heavy metals (in fruits) were within the range of the permissible limits according to the World Health Organization (WHO Geneva, 1993). These results are in agreement with those obtained by (Elgala *et al*., 2003), who found that Fe and Cu concentrations in clover tissues grown in Elgabal Elasfar soil were within the permissible limits. Also these results are in agreement with those reported by El-Motaium and Badawy (2000).They found that heavy metals (Fe, Mn, Cu, Zn, Cd, Ni, and Pb) accumulation in orange trees, roots, were within the permissible limits according to the World Health Organization (WHO Geneva, 1993).

Effect of different irrigation water qualities on Yield and fruit quality of different date palm cultivars:

The data in Table (7) shows the average values of bunch weight and fruit yield/palm (kg) as affected by irrigation water qualities, date palm cultivars (cvs), and their interaction. The data reveals that bunch weight and yield/palm were significantly affected by the irrigation water qualities. Where use of ground water recorded the highest values in this respect (6.41 and 78.44 kg, respectively); however the (GW+TTWW) came in the second rank (6.21 and 76.46 kg, respectively).

The previous characters were significantly affected by different palm cultivars. These differences between cultivars may be due to genotypes. Khalas cultivar gave the heaviest bunch weight in comparison with the other cultivars; whereas Ruzeiz produced the highest yield /palm due to the leave, 14 bunch /palm. The data cleared that Ruzeiz recorded the highest value of yield /palm over all different irrigation water. The interaction between water irrigation qualities and date palm cultivars had a significant effect on bunch weight and fruit yield/palm. Moreover, the ground water encouraged the development of fruits then the bunch weight and finally total yield of all cultivars under the study.

Table 7: Effect of water irrigation qualities, date palm cultivars and their interaction on bunch weight and yield/palm at Tamr stage.

Characters / Treatments		Bunch weight (kg)	Yield weight/palm (kg)
A: Water irrigation qualities:			
GW		6.41 a	78.44 a
GW+DW		5.18 d	63.85 d
GW+TTWW		6.21 b	76.46 b
GW+DW+TTWW		5.65 c	69.34 c
LSD at 5%		0.11	1.31
B: Cultivars:			
Khalas		6.50 a	71.56 b
Sheshi		5.33 c	63.93 c
Ruzeiz		5.76 b	80.58 a
LSD at 5%		0.09	1.14
C: Interaction AxB:			
GW	Khalas	7.38 a	81.16 c
	Sheshi	5.82 e	69.87 f
	Ruzeiz	6.02 d	84.31 b
GW+DW	Khalas	5.32 fgh	58.54 i
	Sheshi	4.97 i	59.60 hi
	Ruzeiz	5.25 gh	73.42 e
GW + TTWW	Khalas	6.95 b	76.51 d
	Sheshi	5.39 fg	64.67 g
	Ruzeiz	6.30 c	88.20 a
GW + DW + TTWW	Khalas	6.36 c	70.04 f
	Sheshi	5.13 hi	61.60 h
	Ruzeiz	5.46 f	76.38 d
LSD at 5%		0.18	2.27

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

From the above results the reduction in yield of palm trees irrigated with (GW+DW) or (GW+DW+TTWW) compared with (GW) or (GW+TTWW) may be attributed to the reduction in palm growth caused by high salinity in irrigation water which have reached up to 5.04 and 4.21 dS m^{-1} for (GW+DW) and (GW+DW+TTWW) respectively, and may be due to the reduction in the rate of photosynthesis. Similar results were obtained by Hassan and El-Samnoudi (1993) and Harhash and Abdel-Nasser (2007) on Seewy date palm cultivar.

The reduction of growth and yield as a result of high salinity conditions may be also due to the increase in the osmotic potential of the soil solution that caused a marked depression in water absorbing power of the roots (Bernstein *et al*., 1956). In the same time, the salinity can decrease the activity of some key enzymes of the Calvin cycle (Plaut and Grieve, 1988).Singh and Mishra, (1979) reported that the yield decrease with increasing the Na content in soil solution under salinity conditions due to the specific ion effect. Furthermore, salinity acted dynamically with a long-term consequence of increasing relative negative response to water consumption and plant growth that may be explained either as an accumulated effect or increasing sensitivity (Tripler *et al*., 2011).

Effect of different irrigation water qualities on Fruit physical properties at Tamr stage of different date palm cultivars:

The data in Table (8) shows the means values of fruits characters as affected by the different irrigation water qualities, palm cultivars and their interaction during the two seasons at Tamr stage. It seen that the fruit weight, length, pulp and seed weight have been significantly affected by the irrigation water qualities. The irrigation by groundwater was superior in this respect as compared with the other different irrigation water. The mixture of (GW and TTWW) came in the second rank.

With respect to the interaction between the two factors under this study, the data reveals a significant effect on all presented characters in Table (8). In this concern, the irrigation with groundwater markedly produced the highest values for all cultivars. Sheshi gave the highest values in most physical properties at tamr stage, when irrigated with ground water.

Table 8: Effect of water irrigation qualities, date palm cultivars and its interaction on physical properties at Tamr stage (over two seasons).

Characters Treatments		Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Pulp weight (g)	Seed weight (g)	Pulp/ seed ratio
A: Water irrigation qualities:							
GW		9.20 a	32.2 a	20.3 a	8.37 a	0.80 a	10.4 a
GW+DW		7.38 b	30.5 b	19.5 a	6.80 b	0.72 b	9.4 a
GW+TTWW		7.78 b	31.6 ab	19.5 a	7.09 b	0.72 b	10.0 a
GW+DW+TTWW		7.62 b	31.2 b	19.4 a	6.88 b	0.70 b	9.9 a
LSD at 5%		0.88	1.7	1.1	0.86	0.07	1.5
B: Cultivars:							
Khalas		8.29 a	34.5 a	19.2 b	7.51 a	0.78 a	9.6 a
Sheshi		8.15 a	32.0 b	20.3 a	7.53 a	0.71 b	10.6 a
Ruzeiz		7.55 a	28.3 c	19.5 ab	6.81 a	0.72 b	9.6 a
LSD at 5%		0.76	0.9	0.9	0.74	0.06	1.3
C: Interaction AxB:							
GW	Khalas	9.59 ab	37.1 a	19.4 bcd	8.70 ab	0.86 a	10.1 abc
	Sheshi	10.59 a	34.9 ab	21.6 a	9.74 a	0.80 ab	12.1 a
	Ruzeiz	7.43 cde	27.6 e	19.8 abcd	6.66 cde	0.73 abc	9.1 bc
GW+ DW	Khalas	7.81 cd	33.5 b	20.3 abc	7.04 bcde	0.77 abc	9.1 bc
	Sheshi	5.95 e	28.1 e	18.4 cd	5.64 de	0.67 bc	8.5 c
	Ruzeiz	8.39 bc	29.8 cde	19.7 abcd	7.72 bc	0.74 abc	10.6 abc
GW + TTWW	Khalas	8.28 bc	35.1 ab	19.1 bcd	7.56 bc	0.76 abc	9.9 abc
	Sheshi	8.81 bc	32.9 bc	21.0 ab	8.13 bc	0.71 bc	11.9 ab
	Ruzeiz	6.26 de	26.7 e	18.3 cd	8.57 e	0.68 bc	8.2 c
GW + DW + TTWW	Khalas	7.48 cde	32.2 bcd	17.9 d	6.76 cde	0.73 abc	9.2 abc
	Sheshi	7.26 cde	32.0 bcd	20.1 abc	6.60 cde	0.66 c	10.1 abc
	Ruzeiz	8.11 bc	29.3 de	20.3 abc	7.28 bcd	0.71 bc	10.4 abc
LSD at 5%		1.53	3.0	1.8	1.49	0.12	2.6

Within each column, means with the same letter are not significantly different ($p \leq 0.05$)

Effect of different irrigation water qualities on Fruit chemical properties at Tamr stage of different date palm cultivars:

The data listed in Table (9) shows that the average values of moisture percentage were significantly higher with all irrigation water qualities; where the TSS doesn't reach the significantly level. The fruits of the date palm grown in the farms irrigated with ground water had more moisture content; on other hand the (GW+DW) produced fruits more dry. Khalas fruits contained the lowest moisture percentage and the highest TSS compared with the other cultivars under this study.

Regarding the interaction between the irrigation water qualities and date palm cultivars, the data in the Table (9) indicate that there are significant differences between the different date palm cultivars. The Ruzeiz cultivar recorded the highest values of moisture content. This was true with all irrigation water qualities particularly in case of groundwater; but the TSS was high in Khalas cultivar.

Also the data of Table (9) show that the total amount of sugars content (either reducing or non-reducing) of date palms irrigated by ground water was significantly higher than the other irrigation water types. However,

Table 9: Effect of water irrigation qualities, date palm cultivars and its interaction on fruit chemical properties at Tamr stage (over two seasons).

Characters Treatments		Moisture %	TSS (%)	Total Sugars %	Reducing sugars %	Non-Reducing sugars %
A: Water irrigation qualities:						
GW		16.92 a	52.67 a	71.31 a	68.09 a	3.22 a
GW+DW		12.51 c	52.35 a	68.78 b	65.85 b	2.93 a
GW+TTWW		13.51 bc	53.14 a	68.90 b	67.49 a	1.41 b
GW+DW+TTWW		14.58 b	52.76 a	68.54 b	67.96 a	0.58 c
LSD at 5%		1.19	0.74	0.79	0.65	0.38
B: Cultivars:						
Khalas		13.16 c	54.14 a	70.40 a	0.69.48 a	0.93 c
Sheshi		14.23 b	51.95 b	69.53 b	66.67 b	2.86 a
Ruzeiz		15.75 a	52.10 b	68.21 c	65.90 c	2.32 b
LSD at 5%		1.03	0.64	0.68	0.56	0.33
C: Interaction AxB:						
GW	Khalas	14.77 bcde	53.43 bcd	71.89 a	70.35 a	1.54 cd
	Sheshi	15.70 b	52.37 defg	72.43 a	68.26 cd	4.17 a
	Ruzeiz	20.30 a	52.20 defg	69.60 cd	65.66 g	3.94 a
GW+ DW	Khalas	11.77 f	53.78 abc	71.64 ab	70.31 a	1.33 cde
	Sheshi	13.17 cdef	51.44 fg	67.29 e	62.78 i	4.51 a
	Ruzeiz	12.60 ef	51.83 efg	67.42 e	64.46 h	2.96 b
GW + TTWW	Khalas	12.77 def	54.87 a	68.25 de	67.53 de	0.72 ef
	Sheshi	12.67 ef	52.94 cde	70.30 bc	68.76 bc	1.54 cd
	Ruzeiz	15.10 bc	51.63 efg	68.16 e	66.19 fg	1.97 c
GW + DW + TTWW	Khalas	13.33 cdef	54.47 ab	69.83 c	69.71 ab	0.12 f
	Sheshi	15.40 bc	51.04 g	68.11 e	66.89 ef	1.22 de
	Ruzeiz	15.00 bcd	52.76 cdef	67.68 e	67.29 def	0.39 f
LSD at 5%		2.06	1.27	1.37	1.12	0.66

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

Khalas cultivar produced the highest values of both total and reducing sugars (70.40 and 69.48%, respectively) than those of the other cultivars (Sheshi and Ruziez).

The lowest value of non-reducing sugars was also obtained with Khalas cultivar. As regard to the interaction between the two factors in case of Khalas palms irrigated by GW was highly significant. This was true in case of both total and reducing sugars. On the other hand, the Sheshi cultivar irrigated with (GW+DW) gave the lowest values in case of reducing sugars, but it recorded the highest value of non-reducing sugar (4.51%) without any significantly different with GW (4.17%).

The previous results revealed that the reduction of chemical properties may be due to the high values of EC in (GW+DW), (GW+TTWW)and (GW+DW+TTWW) as compared with (GW), which produced the best values in these respect. These results were in accordance with those obtained by Harhash and Abdel-Nasser (2007).

From the previous results of yield and fruit qualities, it can be concluded that the (GW) almost produced the highest values in bunch weight, yield/palm and physical characters at Tamr stage. This is due to low value of EC. These results are in agreement with those obtained by Abu - Rekob and Kerdany (2009) with date palm and Rusana *et al.* (2007) with barley. They mentioned that (TTWW) increased the content of elements in these plants. This is most probably due to the fact that (GW) has the least soluble salts, which proved to be harmful to plants. Also (GW) cotains the least concentration of heavy metals, and some ions that adversely affect crop yield such as Na^+ and Cl^- (though these might be within the permissible limit), but their concentration is higher in the other types of irrigation water compared to (GW).The prolonged irrigation with water of high salts is always accompanied by yield reduction in most crops (FAO soil bulletine #39, 1988).

Conclusion

The obvious influence of different irrigation water qualities: groundwater (GW), groundwater/agricultural drainage water (GW+DW), groundwater/ tertiary-treated wastewater (GW+TTWW), and groundwater /agricultural drainage water/tertiary-treated wastewater (GW+DW+TTWW) on macro and micronutrients, as well as some heavy metals' contents in leaves and fruits, and yield and fruit quality of three date palm cultivars (Khalas, Sheshi and Ruzeiz) at Tamr ripening stage are significantly affected by long-term use of different irrigation qualities in agriculture process.

In addition, continuous irrigation with tertiary- wastewater or agricultural drainage water may lead to the accumulation of salts, plant nutrients and heavy metals beyond crop tolerance levels. Therefore, these concerns should be essential components of any management of this irrigation water quality. On the other hand, plant growth, soil fertility and productivity can be enhanced with properly managing these irrigation water qualities, through increasing the levels of plant nutrients and soil organic matter. Based on these results it can be concluded, that proper management of this irrigation water qualities, and periodic monitoring of soil fertility and quality parameters are required to ensure successful, safe, and long term reuse of this irrigation water qualities for irrigation. Considering the variation in the chemical composition of the tertiary-wastewater agricultural drainage water, reuse management should account for the N, P, and K contents prior to the determination of the rate of wastewater addition or fertilization programmer application.

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