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OPTIMIZATION OF USING LOW QUALITY WATER ON IRRIGATING SOILS UNDER DRIP IRRIGATION

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ABSTRACT

Lysimeter experiments were carried out at Sakha Agric. Res. Station in winter season of 1999/2000 for sugar beet and Canola to study the effect of irrigation by different water qualities in four types of soils on yield of both crops, water relations, soil salinity and the elemental contents of soil and plant. The experiment was conducted in a spilt plot design in four replications. Soil types; clayey, loamy, sandy and calcareous were the main plots. The sub plot treatments included different water qualities; fresh water, sewage water, agricultural drainage water and blended sewage with drainage water at ratios of 1: 1 and 2: 1. The obtained data revealed that the EC_w and SAR of low quality water were 3 times of that of fresh water. Also, irrigation with blended sewage water with drainage water at ratio of 2: 1 produced the highest sugar beet root yield. Moreover, the irrigation with drainage water produced the highest root weight per plant and sucrose percentage.

The highest seed yield of Canola was obtained with irrigation with sewage water under both of clay and loamy soil. While the lowest seed yield was recorded with drainage water under both of sandy and calcareous soils.

Concerning water consumptive use, data indicated that the irrigation with fresh water under clayey soil recorded the highest value of water consumptive use for both crops, while the lowest value was obtained by using of blended sewage water with drainage water at ratio of 2: 1.

Irrigating of sugar beet with blended sewage water and drainage water under clayey soil achieved the highest value of crop water use efficiency. Whereas, irrigation with sewage water recorded the highest value of crop water use efficiency for Canola.

Regarding the changes occurred in soil constituents, data clearly showed a relative decrease in ECe, Ca^{2+} and Mg^{2+}, while the reverse trend is true for Na^{+}. These changes are more pronounced in soil irrigated with sewage and drainage water.

Special optimization for increasing the available contents of micro-nutrients (Fe, Mn, Zn and Cu) and non-nutritive heavy metals (Cd, Ni, Pb and Co) in soils irrigated with low quality waters.

Data obtained from the elemental composition of plants revealed that the relative high content of heavy metals in the sewage effluent supports the active uptake of non nutritive metals in the plant tissues grown in the soils irrigated with the studied low quality waters.

Keywords: Soil types, low quality waters, water use efficiency, heavy metals in soils and plants.

INTRODUCTION

Agriculture has to face scarcity of fresh water in Egypt. Looking to the future water demand, it is obvious that rational use of the available water resources is essential. Consequently, proper water management is strongly needed. The use of agricultural drainage and treated wastewater offers a reasonable resource and consequently gives a partial solution of water scarcity in Egypt, (Abd El-Samie 1995; Abou-Zeid, 1995 and El-Mowelhi *et al*., 1995). Also, blending is a simple practice to obtain a composite water suitable for irrigation. The goals of blending are to improve the usability of low quality water and to save considerable amount of fresh water. In this regard, drip irrigation is one of main important factors to be considered when marginal water is employed. The drip irrigation provides the best possible conditions of total soil water potential for a given quality of irrigation water (Shalhevet, 1991).

Determination of usability of water for irrigation is done on the basis of crop tolerance to salinity and irrigation water salinity (Ayers and Westcot, 1985; Maas, 1990; Pratt and Suarez, 1990). The use of sewage water for irrigation is preferred in sandy soils owing to lower elemental accumulation. Care must be given to application of sewage water sources on calcareous soil particularly raw sewage and settlement treatments (Rady *et al*., 1994). Addition of sewage and drainage water has been found to improve the physical conditions of most soils (Epstein, 1975 and Gupta *et al*., 1977) and to influence their chemical properties (Abdel-Naim, 1988 and Labib *et al*., 1992). Sugar beet and Canola as newly winter crops at North Delta can play an important role to partially cover or reduce the gab between national production and consumption of sugar and oil. Heavy metals reach soil either from dust-fall, chemical fertilizers and/or irrigation water, especially those of lower quality. Accumulation of such materials may decrease soil suitability for crop production (Farida Rabie *et al*., 1996).

The aim of this investigation was to evaluate the appropriate cultivated crops (sugar beet and Canola) and its water relations in different soil types under different water qualities. Also, to throw light on the build up of some pollutants in both soils and plants.

MATERIALS AND METHODS

Lysimeter experiments were carried out at Sakha Agric. Res. Station in winter season (1999/2000). Forty lysimeter units with 2m length, 1 m width and 2 m depth were used in this study. Lysimeters were divided into four groups, each group was filled with different soils. Chemical and physical properties of each soil type were determined according to Black (1965) and listed in Tables (1a and 1b).

Table (1a): Chemical properties of different soils.

Types of soil	Soluble cations (meq/L)				Soluble anions (meq/L)				EC,* dS/m	pH in 1: 2.5 soil water susp.	SAR
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{--}	HCO^-_3	Cl^-	SO^{--}_4	at 25ºC		
Clayey	19.5	8.5	25.0	0.5	-	4.6	20.0	28.9	5.2	7.9	6.68
Loamy	15.0	6.7	20.8	0.5	-	4.7	13.3	25.0	4.0	7.9	6.31
Sandy	7.5	5.6	21.0	0.9	-	2.5	17.5	15.0	3.4	7.5	8.20
Calcareous	8.6	6.5	18.8	1.5	-	1.75	14.0	19.7	3.5	8.1	6.84

Table (1b): Physical properties of different soils.

Types of Soil	Particle size distr. (%)			O.M %	$CaCO_3$ %	Soil text class	Bulk density g/cm^3	Moisture		
	Sand	Silt	Clay					F.C.	W.P.	A.W.
Clayey	24.5	30.2	45.3	1.8	1.96	Clayey	1.20	41.4	21.7	19.7
Loamy	28.4	36.2	35.4	1.2	1.48	Loamy	1.26	35.7	17.8	17.9
Sandy	80.2	10.5	9.3	0.3	6.40	Sandy	1.67	9.3	3.2	6.1
Calcareous	68.4	16.9	14.7	0.5	22.30	S.L.	1.35	20.7	9.2	11.5

A split plot design with four replicates was used under drip irrigation system. Soil types i.e., clayey, loamy, sandy and calcareous were assigned to main plots, whereas water qualities i.e. fresh water (F), agricultural drainage water (D) (from main drain No. 7), sewage water (S) and blended sewage water with drainage at ratio of 1: 1 and 2: 1 were allocated in sub-plots. The chemical composition of water sources was done according to the standard procedure as described in Richards (1969) (Table 2).

Sugar beet cultivar (Raspoly) and Canola cultivar (Bactol) were sown on October, 15^{th} 1999. The recommendation of normal agronomic practices for both of sugar beet and Canola were followed. Drip irrigation network consisted of 12 mm lines located adjacent to plant rows. The drippers of 4 L/hr discharge were spaced in 25 cm intervals along the laterals. Drip irrigation started 10 days after germination and was done at 50-60% depletion of available water.

Characters studied:

I. Sugar beet:

- Root yield (kg/plot).
- Sucrose percentage.
- Sugar yield (kg/plot).

II. Canola:

- Seed yield (kg/plot).
- Plant height in cm.
- No. of branches/plant.

Data were statistically analyzed according to Snedecor and Cochran (1967). Irrigation water applied was determined using a flow meter and actual water consumptive use was computed according to the equation of Israelsen and Hansen (1967).

$$Cu = \frac{\theta_2 - \theta_1}{100} \text{ X Db x D X A}$$

Where:

Cu : Water consumptive use (m^3/fed.).
θ_2 : Soil moisture (%) after irrigation.
θ_1 : Soil moisture (%) before the next irrigation.
D_b : Bulk density of soil (g/cm^3).
D : Depth of soil (cm).
A : Irrigation area (m^2).

Water use efficiency (WUE): was computed for the different treatments by dividing the yield (kg/fed) by water consumptive use (m^3/fed) according to Abd El Rasool *et al*. (1971).

Before planting and after harvesting, soil samples were taken from each lysimeter for chemical analysis (ECe dS/m and soluble ions in soil paste extract) according to Black (1965).

Available content of trace elements in soil sample was estimated according to the method of Lindsay and Norvell (1978), using atomic absorption spectrophotometer.

Plant samples of sugar beet root and seeds of Canola were wet digested and analyzed for the trace elements (Chapman and Pratt, 1961).

RESULTS AND DISCUSSION

Evaluation of water resources:

Data given in Table (2) showed the chemical composition of the irrigation waters under consideration. The suitability of water for irrigating different crops can be determined by plotting its chemical composition (EC and SAR) on USDA diagram, according to Richards (1969). Nile water is classed as C_2S_1; medium-salinity low sodicity water. While sewage and drainage water are classed as C_3S_1; high salinity low-sodicity water. To use this water for irrigation, adequate drainage system and special soil and water management are required for salinity control. Also, plants with high salt tolerance should be selected. Data revealed that the micro and macroelements have different concentrations in different water resources but they take the same descending trend as follows: Fe > Mn > Zn > Cu > Pb > Cd > Ni > Co. Also, according to the save scale of FAO (1992) the obtained values of these elements are within the permissible limits.

A. Sugar beet crop:

Sugar beet yield:

Sugar beet root yield as affected by different water sources and soil types are presented in Table (3). Data revealed that blending sewage water with drainage water at ratio of (2: 1) produced the highest sugar beet root yield (9.05 kg/plot) followed by blended water at ratio of (1: 1). Concerning the soil type, the clayey and loamy soils achieved the highest root yield (10.1 and 9.3 kg/plot, respectively).

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Table (3): Effect of different water sources on sugar beet root yield and its components under different soil types.

Treatments		Sugar beet root yield kg/plant	Root weight per plant (kg)	Sucrose percentage	Sugar yield, kg/plot
Soil types					
Clayey		10.1	1.33	15.94	1.61
Loamy		9.3	1.18	16.08	1.52
Sandy		7.4	1.05	16.40	1.22
Calcareous		7.7	1.31	16.46	1.27
Mean		8.63	1.22	16.22	1.41
F. test		*	*	-	*
LSD	0.05	2.2	0.43	-	0.03
	0.01	-	-	-	-
Water sources					
F		8.38	1.25	15.63	1.31
S		8.35	1.10	16.03	1.34
D		8.43	1.36	16.93	1.43
S: D1: 1		8.93	1.2	16.33	1.45
S: D2: 1		9.05	1.19	16.2	1.5
Mean		8.63	1.22	16.22	1.41
F. test		-	*	*	*
LSD	0.05	-	0.21	0.15	0.1
	0.01	-	-	-	-
S X W		-	*	-	*

Average root weight per plant:

Data in Table (3) showed that water sources, soil types and their interactions significantly affected root weight per plant. Data revealed that drainage water produced the highest weight of sugar beet root (1.36 kg root/plant) followed by fresh water. Also, clayey and calcareous soils recorded the highest values of root weight (1.33 and 1.31 kg root/plant, respectively).

Sucrose percentage and sugar yield:

Sucrose percentage showed insignificant response for different soil types. According to statistical analysis, sandy and calcareous soils produced the highest content of sucrose percentage compared to the other soil types. With regard to the effect of water sources, data showed that the use of low quality water significantly increased sucrose percentage in sugar beet roots as compared to fresh water.

It is quite noticeable from data illustrated in Table (3) that sugar yield had considerable response to different water sources. The highest sugar yield was obtained with drainage water if it mixed with sewage water or not while the lowest yields was recorded with fresh water. Concerning soil types, the highest sugar yield were achieved from clayey and loamy soils (1.61 and 1.52 kg/plot, respectively).

The interactions between soil types and water quality significantly affected root weight and sugar yield. These results are in general agreement with those reported by Ibrahim *et al*. (1993) and Khalifa and Ibrahim (1995).

Water relations:

Water consumptive use:

It could be observed from Table (4) that the actual water consumptive use of sugar beet tended to be increased with fresh water (1985.3 m^3/fed), while it was declined by blending sewage water with drainage water at ratio of 2: 1 (1825.4 m^3/fed). The actual water consumptive use values as affected by water quality were took the following descending order: F > D > S: D (1: 1) > S > S: D (2: 1). These findings can be attributed to that the soluble salts in drainage and sewage water accumulate in the root zone, consequently plant spent extra efforts for extracting water from the salty soil solution. Concerning the actual water consumptive use for different soil types, data indicate that the highest water consumptive use values were occurred with clayey soil followed by loamy soil and the lowest value was found under sandy soil. According to the interaction effect, data revealed that the irrigation by fresh water under clayey soil recorded the highest value of water consumptive use by sugar beet (2186.1 m^3/fed), while the lowest value (1656.9 m^3/fed.) was recorded by blending sewage water with drainage water at ratio of (2: 1) under sandy soil. These results were similar to those obtained by Eid (1994) and Abo-Soliman *et al*. (1996).

Table (4): Actual water consumptive use (m^3/fed) for sugar beet as affected by different water sources under different soil types.

Soil types	Different water sources					Mean
	F	D	S	S: D (1: 1)	S: D (2: 1)	
Clayey	2186.1	2107.35	1946.7	2034.9	2025.45	2060.1
Loamy	2142.0	1962.45	1943.55	1883.7	1896.3	1965.6
Sandy	1754.55	1704.15	1713.6	1682.1	1656.9	1702.26
Calcareous	1858.5	1789.2	1748.25	1770.3	1723.05	1777.86
Mean	1985.29	1890.79	1838.03	1842.75	1825.43	1876.46

Water use efficiency (WUE):

It could be observed from data presented in Table (5) that the clayey and loamy soils realized the highest values of water use efficiency for root yield (10.32 and 9.75 kg/m^3), respectively. Moreover, the highest values of water use efficiency for sugar yield were detected with clayey and loamy soils (1.65 and 1.64 kg/m^3, respectively). The irrigation with blending sewage with drainage water at ratio of (1:1) and (2:1) scored the highest values for root yield (10.1 and 10.1 kg/m^3, respectively), while it reached 1.65 and 1.72 kg/m^3 with the treatments of S: D (1:1) and (2: 1), respectively. Respecting to combined effect, data showed that the highest value of (WUE) for root yield was detected by blending sewage and drainage water at ratio of (1: 1) under clay soil. While, for sugar yield the highest value (1.94 kg/m^3) was achieved by the combination between blended sewage water added to drainage water and loamy soil.

Table (5): Water use efficiency for beet and sugar yield (kg/m^3) for different treatments.

Soil types	Water use efficiency for beet yield					Mean	Water use efficiency for sugar yield					Mean
	F	D	S	S: D (1: 1)	S: D (2: 1)		F	D	S	S: D (1: 1)	S: D (2: 1)	
Clayey	9.22	9.47	10.89	11.56	10.47	10.32	1.4	1.59	1.7	1.87	1.67	1.65
Loamy	8.92	10.06	8.97	10.48	10.3	9.75	1.39	1.73	1.42	1.71	1.94	1.64
Sandy	8.5	8.87	9.31	8.99	10.01	9.14	1.36	1.49	1.53	1.46	1.67	1.50
Calcareous	8.7	8.92	8.89	9.37	9.63	9.10	1.37	1.5	1.47	1.54	1.61	1.5
Mean	8.84	9.33	9.52	10.1	10.1	9.58	1.38	1.58	1.53	1.65	1.72	1.57

B. Canola crop:

Seed yield:

Data in Table (6) showed that water sources, soil types and their interactions significantly affected seed yield of canola. The highest seed yield (0.512 kg/plot) was obtained when soils were irrigated with sewage water, while the lowest values were obtained from irrigation with drainage water or sewage water blended with drainage water at ratio of (2: 1). Concerning the soil types, data indicated that clay and loamy soils gave the highest seed yields (0.618 and 0.542 kg/plot, respectively). The interaction between different water sources and soil types was significant. It can be concluded that the highest values of seed yield were obtained with sewage water under both clayey and loamy soils. While the lowest seed yield was recorded with drainage in both sandy and calcareous soils. These results are somewhat similar to those obtained by Ibrahim *et al*. (1988) and El-Mowelhi *et al*. (1998).

Table (6): Effect of water sources on seed yield of Canola and its component under different soil types.

Treatments		Seed yield, kg/plot	Plant height, Cm	No. of Branches
Soil types (S)				
Clayey		0.618	158.06	6.0
Loamy		0.542	159.88	5.86
Sandy		0.328	150.52	4.60
Calcareous		0.467	154.14	5.57
Mean		0.467	155.65	5.51
F. test		**	**	**
L.S.D.	0.05	0.0017	0.689	0.0939
	0.01	0.0022	0.948	0.1297
Water sources (W)				
F		0.456	159.45	5.68
S		0.512	165.88	5.82
D		0.433	154.73	5.44
S: D (1: 1)		0.460	148.68	5.15
S: D (2: 1)		0.475	149.53	5.45
Mean		0.467	155.65	5.51
F. test		**	**	**
L.S.D.	0.05	0.0017	0.635	0.07
	0.01	0.0022	0.850	0.09
S X W		**	**	**

Plant height:

It is obvious from data presented in Table (6) that the water sources significantly affected plant height. The tallest plants (165.88 cm) were obtained with sewage water followed by fresh water (159.45 cm). Concerning soil types, data revealed that the tallest plants (159.88 cm) were achieved with loamy soil, followed by clayey and calcareous soils.

Number of Branches:

Data in Table (6) revealed that the highest number of branches/plant (5.82) was achieved with sewage water followed by fresh water (5.68), while the lowest one (5.15) was obtained by blending sewage and drainage water at ratio of (1: 1). Respecting to soil types effect, the highest number of branches/plant (6.0 and 5.86) were obtained from clayey and loamy soils, respectively.

Water consumptive use:

Water consumptive use by Canola plants as affected by water sources and soil types are presented in Table (7). Data revealed that the highest values was obtained when plants irrigated by fresh water (1525.51 m^3/fed). While the lowest water consumptive use value (1386.3 and 1406.0 m^3/fed) was found with sewage water and drainage water, respectively. Concerning the soil types, data indicated that the plants grown in clayey and loamy soils consumed water more than that of sandy and calcareous one. This variation in water consumptive use can be related to the availability of moisture in different soils.

Table (7): Water consumptive use (m^3/fed.) for Canola crop as affected by different water sources under different soil types.

Soil types	Different water sources					Mean
	F	D	S	S: D (1: 1)	S: D (2: 1)	
Clayey	1779.75	1638.42	1737.10	1732.89	1622.04	1702.04
Loamy	1645.05	1452.27	1458.54	1505.95	1645.14	1541.39
Sandy	1276.92	1162.93	1110.64	1205.11	1276.80	1206.48
Calcareous	1400.33	1370.35	1238.92	1354.66	1400.28	1352.91
Mean	1525.51	1405.99	1386.30	1449.65	1486.07	1450.70

Water use efficiency:

It could be noticed from Table (8) that maximum water use efficiency was scored from clayey soil (0.76 kg/ m^3) followed by loamy soil (0.74 kg/m^3). While the minimum value was obtained from sandy soil (0.57 kg/ m^3). Also, the values of water use efficiency under different water sources possesses the following descending trend S > S: D (2: 1) > S: D (1: 1) > D > F.

Table (8): Water use efficiency (kg/m^3) for Canola crop as affected by different water sources under different soil types.

Soil Types	Different water sources					Mean
	F	D	S	S: D (1: 1)	S: D (2: 1)	
Clayey	0.70	0.73	0.82	0.75	0.82	0.76
Loamy	0.68	0.75	0.89	0.71	0.68	0.74
Sandy	0.53	0.56	0.62	0.58	0.58	0.57
Calcareous	0.58	0.51	0.71	0.59	0.58	0.59
Mean	0.62	0.64	0.76	0.66	0.67	0.67

Effect of irrigation water quality on some chemical properties of soils:

It is quite noticeable from data illustrated in Table (9) that the salt content in soil for almost all treatments after harvesting are relatively lower than those recorded before planting. Concerning the quality of irrigation waters, the lowest values of ECe were recorded with fresh water in different soil types, while the highest values were related to drainage water if it was used directly or blended with sewage water. Also, irrigation with low quality water is more pronounced to increase soluble Na^+, especially in fine texture soil, while the reverse trend was found for the Ca^{2+}, Mg^{2+}, Cl^- and SO_4^{2-} ions since they were lower than their values before planting. With regard to the balance between the cations in soil solution, it could be noticed that the lowest values of SARe were obtained with fresh water, while the highest values were detected with the direct use of drainage water or after blending with sewage water. This behaviour may be related to the relative high contents of soluble sodium in drainage and sewage waters. Therefore, suitable soil amendment should be applied during the usage of this water to avoid the alkalinity hazard. These results are in agreement with Balba (1990), who reported that soil salinity may be decreased if the irrigation water salinity was lower than the salt concentration of the soil.

Table (9): Chemical analysis of soil paste extract of the studied soils as affected by the quality of irrigation waters.

Water Sources	EC dS/m	Cations, meq/L				Anions, meq/L				SAR
		K^+	Na^+	Ca^{++}	Mg^{++}	$CO^{=}_3$	HCO^-_3	Cl^-	$SO^{=}_4$	
Clayey soil										
Before	5.2	0.5	25.0	19.5	8.5	-	4.6	23.0	25.9	6.68
F	3.4	0.5	19.6	10.8	4.1	-	5.0	12.4	17.6	7.18
S	4.2	0.5	26.0	12.5	7.5	-	5.0	21.0	20.5	8.22
D	4.0	0.3	26.4	10.0	5.8	-	5.0	18.5	19.0	9.39
S: D (1: 1)	4.5	0.5	27.0	12.3	8.7	-	6.0	21.0	21.5	8.33
S: D (2: 1)	4.8	0.5	29.0	13.0	7.0	-	4.0	19.0	26.5	9.17
Loamy soil										
Before	4.0	0.5	20.8	15.0	6.7	-	4.7	15.3	23.0	6.31
F	2.8	0.5	17.0	6.5	4.4	-	4.5	12.3	11.6	7.28
S	3.0	0.3	19.4	6.7	4.6	-	4.5	14.0	11.5	8.16
D	3.6	0.6	22.4	8.5	5.2	-	4.5	15.0	17.2	8.55
S: D (1: 1)	3.5	0.5	20.6	6.7	5.7	-	5.2	13.5	14.8	8.27
S: D (2: 1)	3.8	0.5	23.4	9.5	5.2	-	5.0	14.0	19.6	8.63
Sandy soil										
Before	3.4	0.9	21.0	7.5	5.6	-	2.5	17.5	15.0	8.20
F	1.8	0.9	11.4	3.4	2.8	-	2.4	11.5	6.6	6.47
S	2.5	0.5	15.0	4.5	5.0	-	5.5	10.0	9.5	6.88
D	3.1	0.6	18.4	7.4	5.2	-	4.0	15.6	12.0	7.33
S: D (1: 1)	2.8	0.6	16.0	6.2	5.4	-	3.5	14.2	10.8	6.64
S: D (2: 1)	3.0	0.9	17.8	7.5	4.5	-	5.2	15.0	10.5	7.26
Calcareous soil										
Before	3.5	1.5	18.8	8.6	6.5	-	1.75	14.0	19.7	6.84
F	2.3	1.0	13.4	6.6	3.2	-	1.6	10.4	12.2	6.05
S	3.2	1.0	17.5	8.0	6.3	-	1.8	14.5	17.5	6.54
D	3.0	1.2	16.5	7.8	5.0	-	2.0	11.7	16.8	6.52
S: D (1: 1)	2.9	1.5	16.5	7.5	5.5	-	2.0	11.5	17.5	6.47
S: D (2: 1)	3.4	1.5	18.0	8.5	6.0	-	2.2	12.3	19.5	6.69

Soil elemental contents:

Data given in Table (10) indicated that the accumulation of micro-nutrients (Fe, Mn, Zn and Cu), and non nutritive heavy metals (Pb, Co, Ni and Cd) in fine texture soils were remarkably higher with low quality waters than with fresh water. Whereas, a slight increase for the elemental content were recorded under coarse texture soils. These results may be due to the accumulation of organic matter from sewage water that led to decrease soil pH and in turn increase the solubility of the nutrients. These results are in harmony with Mohamed (1982) and Hegazi (1999) who reported that soil texture is the most important factor affecting the content and availability of trace elements. Moreover, the behavior of low quality water in different soil types is fundamentally related to their physical and chemical properties. It could be noticed that concentration of these elements in studied soils, are still within the permissible limits according to FAO (1992).

Table (10): Average values of DTPA extractable elements (ppm) in the studied soils irrigated with different water sources.

Element / Water sources	Fe	Mn	Zn	Cu	Pb	Co	Ni	Cd
Clayey soil								
F	18.6	20.5	2.8	2.2	1.9	1.05	2.9	0.13
S	23.3	24.8	4.8	4.2	3.8	2.4	4.4	0.30
D	20.8	22.6	3.5	3.2	3.0	1.2	4.0	0.15
S: D (1: 1)	21.2	23.0	4.3	3.6	3.4	1.7	4.2	0.23
S: D (2: 1)	22.5	23.9	4.5	4.0	3.8	2.1	4.3	0.28
Loamy soil								
F	16.5	14.2	2.6	2.5	1.7	1.1	1.5	0.11
S	20.8	20.9	4.6	3.9	2.9	2.5	3.0	0.25
D	18.6	16.6	3.3	3.0	1.8	1.3	2.6	0.15
S: D (1: 1)	19.4	17.3	3.7	3.5	2.7	2.0	2.8	0.12
S: D (2: 1)	20.0	20.4	4.2	3.8	2.8	2.3	3.1	0.23
Sandy soil								
F	3.5	2.9	1.1	1.5	1.0	0.4	1.4	0.07
S	5.8	4.7	1.8	2.4	2.7	1.9	2.6	0.18
D	3.7	3.5	1.2	1.8	2.0	0.5	2.1	0.09
S: D (1: 1)	4.9	3.9	1.0	2.2	2.2	0.9	2.4	0.12
S: D (2: 1)	5.4	4.1	1.5	2.3	2.2	1.2	2.4	0.14
Calcareous soil								
F	2.9	2.0	0.7	1.0	1.4	0.6	0.85	0.10
S	3.6	3.2	1.8	1.8	2.2	0.85	1.9	0.38
D	3.2	2.2	1.0	1.2	1.6	0.80	1.5	0.20
S: D (1: 1)	3.1	2.6	1.2	1.5	1.8	0.84	1.7	0.22
S: D (2: 1)	3.4	2.8	1.2	1.6	2.1	0.84	1.8	0.25

Plant elemental contents:

Undoubtedly, the relative high content of heavy metals in the sewage effluent enhances the uptake of non nutritive metals by plant. Data in Table (11a and 11b) showed a pronounced increase in the contents of micro-nutrients and non nutritive heavy metals (i.e., Fe, Mn, Zn, Cu, Pb, Co, Ni and Cd) in sugar beet roots and seeds of Canola irrigated with low quality waters. These results are in harmony with those obtained by Header (1987) and Hegazi (1999). In general, the concentration of heavy metals in plants is lower than the toxic critical level suggested by Macnicol and Beckett (1985).

Table (11-a): Elemental contents (ppm) in sugar beet root grown in different soils irrigated with different water sources.

Element / Water sources	Fe	Mn	Zn	Cu	Pb	Co	Ni	Cd
Clayey soil								
F	550	23.0	28.0	7.7	2.4	2.0	2.1	0.027
S	810	35.0	46.0	9.5	3.5	2.4	3.2	0.061
D	720	30.0	35.0	8.3	3.2	2.2	2.8	0.028
S: D (1: 1)	740	32.0	42.0	9.1	3.3	2.3	3.0	0.029
S: D (2: 1)	770	32.0	45.0	9.2	3.5	2.3	3.0	0.030
Loamy soil								
F	535	21.0	26.0	7.3	2.0	1.8	2.1	0.025
S	820	33.0	44.0	9.2	3.4	2.2	3.0	0.060
D	700	27.0	35.0	8.1	3.1	2.0	2.6	0.027
S: D (1: 1)	750	30.0	40.0	8.7	3.0	2.1	2.6	0.028
S: D (2: 1)	810	32.0	43.0	8.5	3.2	2.2	2.6	0.028
Sandy soil								
F	325	17.0	22.0	3.4	1.2	0.7	1.2	0.018
S	510	23.0	32.0	5.02	2.0	1.2	1.3	0.040
D	420	21.0	30.0	4.7	1.8	0.9	1.5	0.025
S: D (1: 1)	385	18.0	30.0	4.8	1.8	0.9	1.3	0.023
S: D (2: 1)	460	20.0	33.0	4.8	1.9	1.0	1.4	0.022
Calcareous soil								
F	380	19.0	24.0	4.6	1.6	1.1	1.3	0.023
S	550	24.0	35.0	6.5	2.3	2.3	1.7	0.040
D	430	21.0	32.0	5.8	2.0	1.8	1.4	0.021
S: D (1: 1)	390	22.0	32.0	6.1	2.0	2.0	1.5	0.028
S: D (2: 1)	510	22.0	34.0	6.3	2.3	2.0	1.7	0.028

Table (11-b): Elemental contents (ppm) in seeds of Canola grown in different soils irrigated with different water sources.

Element / Water sources	Fe	Mn	Zn	Cu	Pb	Co	Ni	Cd
Clayey soil								
F	510	22.0	32.0	5.5	1.5	1.3	2.1	0.025
S	760	40.0	47.0	8.7	3.4	3.1	4.2	0.045
D	632	31.0	35.0	5.4	2.9	2.3	3.0	0.025
S: D (1: 1)	670	33.0	40.0	7.7	2.8	2.8	3.2	0.032
S: D (2: 1)	742	36.0	42.0	8.2	3.0	2.8	3.4	0.032
Loamy soil								
F	530	23.0	28.0	5.2	1.3	0.9	2.2	0.022
S	752	36.0	40.0	8.4	3.2	2.9	3.7	0.040
D	617	30.0	32.0	5.5	2.5	2.3	2.2	0.025
S: D (1: 1)	635	32.0	34.0	7.6	2.7	2.5	3.0	0.030
S: D (2: 1)	740	33.0	39.0	8.2	2.7	2.7	3.1	0.035
Sandy soil								
F	350	15.0	17.0	2.7	0.7	0.5	0.6	0.015
S	535	25.0	31.0	4.2	1.5	1.7	1.7	0.035
D	430	22.0	24.0	3.5	1.0	0.9	1.3	0.021
S: D (1: 1)	437	22.0	27.0	3.2	1.1	1.0	1.5	0.022
S: D (2: 1)	477	23.0	27.0	3.9	1.3	1.0	1.5	0.025
Calcareous soil								
F	412	15.0	23.0	3.2	0.9	0.9	1.5	0.021
S	587	20.0	35.0	5.6	1.8	2.1	2.8	0.038
D	422	17.0	26.0	3.6	1.3	1.4	2.2	0.031
S: D (1: 1)	442	20.0	30.0	4.2	1.5	1.8	2.0	0.029
S: D (2: 1)	485	21.0	30.0	4.2	1.5	1.9	2.2	0.034

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الاستفادة من المياه منخفضة الصلاحية فى رى بعض الأراضى تحت نظام الرى بالتنقيط

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أقيمت تجربة أحواض أسمنتية بمحطة البحوث الزراعية بسخا ـ كفرالشيخ فى الموسم الشتوى 2000/1999م وكانت منزرعة بمحصولى بنجر السكر والكانولا تحت نظام الرى بالتنقيط لدراسة تأثير مصادر مختلفة النوعية من مياه الرى فى أربعة أنواع من الأراضى مختلفة القوام على المحصول ومكوناته وبعض العلاقات المائية ، ملوحة التربة ومحتوى التربة والنبات من العناصر الثقيلة.

وكان تصميم التجربة بنظام القطع المنشقة مرة واحدة وأربعة مكررات حيث وضعت أنواع الأراضى فى القطع الرئيسية (طينية ـ طميية ـ رملية ـ جيرية) بينما وضعت مصادر مياه الرى فى المعاملات الشقية (مياه النيل ـ صرف صحى ، صرف صحى ، معالج ـ صرف زراعى ـ خلط مياه الصرف الصحى المعالج والصرف الزراعى بنسبة (1: 1) ، (2: 1).

وقد أظهرت النتائج المتحصل عليها الآتى:

- بمتابعة دلالات ملوحة وقلوية مياه الرى المستخدمة وجد أن هناك زيادة وصلت إلى 3 مرات تقريبا فى مستوى الملوحة والقلوية للمياه قليلة الصلاحية مقارنة بمياه النيل.
- تشير النتائج أن المياه المخلوطة بنسبة (2: 1) أعطت أعلى محصول من بنجر السكر بينما الرى بمياه الصرف الزراعى أعطت أعلى محصول من جذور البنجر لكل نبات وكذلك نسبة السكروز.
- أن الرى بمياه الصرف الصحى المعالج أعطى أعلى محصول من بذور الكانولا فى الأراضى الطينية والطميية ـ بينما أقل محصول كان عند الرى بمياه الصرف الزراعى فى الأراضى الرملية والجيرية.
- أن قيم الاستهلاك المائى كانت أعلى بالرى بمياه النيل فى الأراضى الطينية لكلا المحصولين بينما أقل القيم كانت عند الرى بالمياه المخلوطة (2: 1).
- أن أعلى قيم للكفاءة الاستعمالية لمياه الرى كانت عند الرى بالمياه المخلوطة لمحصول بنجر السكر وعند الرى بمياه الصرف الصحى لمحصول الكانولا.
- بالنسبة لتأثير نوعية المياه على خواص التربة التى تروى منها مقارنة بتلك التى تروى بمياه النيل تشير النتائج إلى حدوث إنخفاض نسبى فى مستوى الملوحة والكالسيوم والماغنسيوم الذائبين والعكس بالنسبة للصوديوم.
- أوضحت النتائج أن محتوى التربة من العناصر الصغرى (حديد ، منجنيز ، زنك ، نحاس) والعناصر الثقيلة (رصاص ، كوبلت ، نيكل ، الكادميوم) قد زاد نتيجة للرى بالمياه منخفضة الصلاحية وخاصة تلك الملوثة بمياه الصرف الصحى بالمقارنة بمياه النيل.
- كما أدت زيادة تلك العناصر بالتربة إلى زيادة معدل امتصاصها بواسطة النباتات النامية ، مما أدى إلى زيادة تركيزاتها فى جذور بنجر السكر وبذور الكانولا التى تروى بهذه النوعيات من المياه قليلة الصلاحية.

Table (2): Chemical analysis of irrigation water source samples.

Water sources	Soluble ions (meq/L)											Heavy metals (mg/L)							
	Anions				Cations				SAR	EC, dS/m	pH								
	$CO^{=}_3$	HCO^{-}_3	Cl^-	$SO^{=}_4$	Ca^{++}	Mg^{++}	Na^+	K^+				Fe	Cu	Mn	Zn	Pb	Ni	Cd	Co
Fresh (F)	-	1.0	1.8	1.9	1.6	0.9	1.9	0.3	1.55	0.5	7.5	0.21	0.006	0.033	0.012	0.012	0.001	0.008	0.008
Sewage (S)	-	5.5	7.0	2.0	2.4	3.2	8.4	0.5	4.97	1.4	7.2	1.9	0.02	0.86	0.32	0.05	0.005	0.03	0.020
Drainage (D)	-	4.6	4.9	2.4	2.55	2.24	6.75	0.36	4.38	1.15	7.7	1.2	0.01	0.03	0.02	0.09	0.003	0.01	0.006
S: D (1: 1)	-	4.2	6.5	2.0	2.8	2.1	7.4	0.4	4.74	1.28	7.4	1.1	0.01	0.15	0.16	0.03	0.001	0.02	0.011
S: D (2: 1)	-	4.25	6.4	2.6	2.4	2.45	8.0	0.4	5.13	1.36	7.3	1.4	0.01	0.35	0.15	0.04	0.001	0.02	0.013