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SOIL PROPERTIES, FLAX VARIETIES PRODUCTION AND THEIR HEAVY METALS CONTENTS UNDER IRRIGATION WITH LOW WATER QUALITY

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ABSTRACT

A lyzimeter experiment was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh governorate, Egypt, during two successive seasons 2011/2012 and 2012/2013. Lyzimeters (100 x 70 x 90 cm) were filled with clayey soil and irrigated with three water types since twenty seven years ago to study the effect of irrigation by different water qualities (fresh water, drainage water and blended water) on soil properties, productivity of flax varieties (Sakha1, Sakha2, Sakha 101, and Sakha 102) and their contents of heavy metals (Pb, Cd, Ni and Cu). The obtained results showed that, using poor quality water for irrigation increased ECe, soluble cations and anions in soil paste extract and DTPA extractable heavy metals (Cu, Ni, Cd and Pb) than that of blended or good water quality. Highl significant differences of yield and yield components among flax varieties were found due to irrigation water qualities and its contents of heavy metals. Heavy metals content was higher in the straw than that of seeds. No significant differences were found among Cd content for all studied flax varieties. No significant differences were found among Cu, Pb and Cd content in straw with all studied flax varieties. Cadmium content in studied flax varieties decreased as follows: Sakha 2 < Sakha 1< Sakha 101 < Sakha 102, while the order was: Sakha 1 < Sakha 2 < Sakha 101 < Sakha 102 for Pb, Cu and Ni. So, Sakha 1 was more tolerant variety to the irrigation with drainage and blended water

Keywords: Water quality, heavy metals, flax varieties, soil characteristics.

INTRODUCTION

Egypt is almost solely dependent on The River Nile as the main water source. Approximately 96% of Egypt's water supply is from that main source. Nearly 85% of the available supply, (approximately 55.5 billion cubic meter annually) is consumed by the agriculture sector (Mona El-Kady and Sameh, 2003). The possibility to increase water supply is limited and conditioned. Moreover the competition for limited water resources is increasing among urban, industrial, and agricultural interests. The drainage water is considered as an important source, which has been used by many countries after mixing with freshwater (El-Nagaawy, 2000). However, great amounts of various pollutants affect the quality of drainage water, which is mostly composed of domestic, industrial and/or agricultural effluents. The major types of toxic pollutants are the heavy metals of Pb, Cd, Zn, Ni, Co, Cr, Mn and Fe which come from industrial processes and agricultural practices (Khan *et al*., 2007).

Use of low water quality in irrigation could be an important consideration when the disposal is being planned in arid and semi arid regions. Using drainage water in irrigation caused high increase in EC and SAR of saturated soil paste extract (Omar *et al*., 2001). Meanwhile, using drainage water in irrigation significantly increase the total and DTPA extractable heavy metals compared with Nile water (Zein *et al*., 2002). Aboulrous *et al.* (1991) showed an increase in levels of heavy metals in soil irrigated with wastewater. Once the ions have been absorbed through the roots or straw and have been transported to the xylem vessels. There is possibility of movement throughout the whole plants. The rate and extent of movement within plants depend on the metal concerned, the plant organ and the age of plant (Chaney and Giordano, 1977). Pollution is defined as any change in physical, chemical or biological conditions of the environment which may harmfully affect the quality of human life including effects upon animals and plants. The untreated industrial drainage water contain little or more amount of heavy metals, which may cause enhancement of their level in the Nile and/or agricultural drainage water when they mixed. Toxic metal pollution of water and soil was a major environmental problem. The main problem concerned with water pollution was heavy metals when water containing these metals, as a pollutants, used for irrigation, it will contaminate and enrich soils and crops (Mireles *et al.,* 2004).

Also, as a result of water shortage, an available alternative is to use of low water quality in irrigation of fiber crops. Generally, fiber crops are non-food crops. Flax "*Linum usitatissimum* L." is a winter fiber and seeds crop. Flax is considered one of the most promising fiber and oil crop in Egypt. It is proposed to close up the gap of oil consumption by planting flax. Also, flax plant can be used successively as a phytoremediation in cleaning the polluted soils with Ni, Pb and Cd. The removal of Ni, Pb and Cd by flax was more pronounced than by jute plants. Whereas flax plant can be removed about 2 times higher for Ni, 7 times higher for Pb and 4 times higher for Cd than that by jute plant (Zein, 2004).

The objectives of the present work are to assess the effect of irrigation with different water qualities on productivity, heavy metals contents of flax varieties and some soil characteristics.

MATERIALS AND METHODS

A lyzimeter experiment was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh governorate, Egypt, and repeated for during two successive seasons 2011/2012 and 2012/2013, to study the effect of irrigation by different water qualities on some soil properties, productivity of some flax varieties (Sakha 1, Sakha 2, Sakha 101, and Sakha 102) and their contents of heavy metals (Pb, Cd, Ni and Cu) in soil, seed and straw of flax. Three water qualities were used for irrigation; fresh water, polluted drainage water and blended water (50% fresh water + 50% drainage water). The study was conducted in cement Lyzimeters (100 x 70 x 90 cm) filled with clayey soil since 1987. Some characteristics of the used irrigation water are presented in Table (1).

The four flax "Linum usitatissimum L." varieties were planted on 25th of November in the two seasons at seeds rate of 60kg/fed. Phosphorus was applied as superphosphate (15.5% P_2O_5) before sowing at rate of 15.5Kg

P_2O_5/ fed. Nitrogen was applied as urea (46.5% N) at rate of 60 Kg N/fed. in two doses (one month and two months after planting) and potassium fertilizer was added in the form of potassium sulphate (48% K_2O) at rate of 24 kg K_2O/ fed. after one month of planting. All other agronomic practices were carried out according to Ministry of Agriculture recommendations. Plants were harvested in 15 May, straw and seeds yields were determined in Kg/fed, number of seed/plant, weight of 1000 seeds, technical length, top capsule zone and number of capsule were recorded. Representative seed and straw samples were collected for chemical analysis. Wetted technique was used for samples digestion as described by Chapman and Pratt (1961). Soil samples were taken from each Lyzimeter before planting and after harvesting, for analysis of total soluble salts, soluble cations & anions in soil paste extract according to Richards (1969), and extracted by DTPA to determine Pb, Cd, Ni and Cu using an Atomic Absorption Spectrophotometer, according to Lindsay and Norvell (1978). Translocation coefficient from straw to seeds (TC%) was calculated as follows:

$$\mathbf{TC\ \% = \frac{Content\ of\ heavy\ metal\ in\ seeds\ (mg/kg)}{Content\ of\ the\ same\ heavy\ metal\ in\ straw\ (mg/kg)} \times 100}$$

Table (1): Chemical characteristics of used water during the two seasons.

Water qualities parameters	EC, dS/m at 25°C	pH	Cation, meq./L				Anion, meq./L				SAR	Water class
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$		
Fresh water	0.50	7.5	1.9	1.27	1.53	0.30	-	2.51	1.41	1.08	1.22	C_2-S_1
Drainage Water	1.80	8.30	5.70	2.8	9.02	0.48	-	4.30	8.3	5.40	4.38	C_3-S_2

	Heavy metal content (mg/L)			
	Cu	Ni	Cd	Pb
Fresh water	0.018	0.007	0.008	0.09
Drainage water	0.280	0.301	0.037	0.900
Critical limits according to FAO (1989)	0.200	0.200	0.010	5.000

A split–plot design with four replicates was used. The irrigation water qualities and flax varieties were allocated in the main and sub main plots, respectively. Statistical analysis was carried out using Irristat- Software, Computer Program (Duncan, 1965).

RESULTS AND DISCUSSION

Fresh and drainage water evaluation:

According to Richard's classification and the data presented in Table (1), fresh water was classed in (C2-S1) medium salinity and low sodicity, while, drainage water was classed in (C3-S2) high salinity and medium sodicity which cannot be used for soils with restricted drainage and crop with good salt tolerant should be selected (Richards, 1969). It can be concluded that fresh water has a good quality, drainage water has a poor quality for irrigation and the mixed water is an intermediate between them. Also data in Table (1) showed that the studied heavy metals Cd, Pb, Ni and Cu contents of drainage water were greater than that of fresh water while the some heavy metals except pb were higher the critical limits, according to FAO (1989), i.e., 0.01, 5.00, 0.2 and 0.2 for Cd, Pb, Ni and Cu mg/L, respectively. The high heavy metal contents in drainage water could be attributed to the pollution sources of industrial and municipal wastes discharged to the drainage system. These results are in agreement with those obtained by El-Mowelhi *et al.*, (1995).

Effect of using water waste on some chemical properties of clay soils:

A- Soil salinity and soluble ions

The changes in electrical conductivity of soil paste extract (dS/m), soluble cations (Ca^{+2}, Mg^{+2}, Na^{+} and K^{+} meq./L) and soluble anions (HCO_3^{-}, Cl^{-} and SO_4^{--}meq./L) before planting and after harvesting are listed in Table (2). Data show that EC values decreased from 4.70 to 4.20 by using fresh water while increased from 5.13 and 5.40 dS/m to 5.35 and 6.26 dS/m due to irrigation by mixed water and drainage water treatments, respectively. The obtained data showed also, that utilization of drainage water for irrigation purposes tend to increase soluble cations and anions Na^{+}, Mg^{++}, So_4^{--} and Cl^{-} than those obtained before planting of flax. All soluble anions were higher in soil irrigated with poor quality water and these results were in harmony with those obtained by Zein *et al*. (2012).

Table (2): Soil chemical analysis before planting and after harvesting of flax under three irrigation water qualities.

Water quality	Cation, meq/L				Anion, meq/L				ECe, dS/m	pH (1:2.5)	SP (%)	Available		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3-	Cl^{-}	So_4--				N ppm	P ppm	K ppm
Before Planting														
fresh water	18.36	11.9	16.30	0.44	-	4.60	14.4	28.00	4.70	8.08	75.70	20	11	325
blended water	20.20	11.0	19.70	0.40	-	4.20	16.70	30.40	5.13	8.15	76.60	26	12	401
Drainage water	21.40	11.50	20.58	0.52	-	4.80	18.10	31.10	5.40	8.21	78.20	27	15	415
After harvesting														
fresh water	15.72	10.40	15.47	041	-	3.53	14.5	23.97	4.20	8.05	76.10	22	12	360
blended water	20.15	11.90	21.06	0.39	-	4.75	17.12	31.63	5.35	810	76.80	27	14	460
Drainage water	21.30	11.60	29.20	0.50	-	5.15	23.24	34.21	6.26	8.20	77.60	28	17	490

B- DTPA- extracted heavy metals from studied soil:

Data in Table (3) show that all values of DTPA extractable heavy metals of soils can be discendingly arranged according to the effect of irrigation by different water qualities as follows: Drainage water > blended water > fresh water before planting and after harvesting of flax. Soil content of heavy metals has followed the sequence Cu > Pb > Ni > Cd in case of fresh water. This trend was different under using drainage and mixed water Pb > Cu > Ni > Cd. The obtained results are in agreement with those of Aboulroos *et al*. (1991) who found that the behavior of Cu and Pb differ from that of Cd, CO and Ni in soils irrigated with sewage effluent, they added that for Cd, Cu and Ni metals, the percentages held in primary minerals fraction were increased with time on the expense of the percentage of other fractions, especially that organically complexed. Although the studied soils were still beyond the critical levels, it could be reached this point upon the continuous using of polluted drainage water.

Table (3): DTPA extractable heavy metal concentrations (mg/kg) before planting (2010) and after harvesting of flax (2012) as affected by using waste water.

Water quality parameters	Available heavy metal content (mg/kg soil)			
	Cd	Ni	Pb	Cu
	Before planting (2010)			
Fresh water	0.092	1.87	3.01	5.20
Blended water	0.145	2.05	8.10	6.56
Drainage water	0.165	2.78	10.20	7.13
	After harvesting (2012)			
Fresh water	0.094	1.61	3.58	5.30
Blended water	0.155	2.10	8.45	6.70
Drainage water	0.170	2.90	11.10	7.33

Effect of using waste water on flax yield and yield components:

The seed yield of flax (kg fed^{-1}) was affected significantly with flax varieties and water quality (Table 4). The highest seed yield (689, 690 kg/fed.) were gained by Sakha 1 under fresh water, while the lowest seed yield (276 and 272 kg/fed.) were obtained from Sakha 102 under drainage water in the first and second seasons, respectively.

Table (4): Effect of different water qualities on yield and yield components of the tested flax varieties in the two seasons.

Varieties	Irrigation water treatments					
	First season			Second season		
	Fresh Water	Blended water	Drainage water	Fresh water	Blended water	Drainage water
Seed yield (kg/fed.)						
Sakha 1	689.0 a	555.5 a	525.0 a	690.0a	551.5 a	520.0 a
Sakha 2	624.0 b	553.0 a	392.5 b	630.0a	551.0 a	392.0 b
Sakha 101	510.0 c	460.0 b	362.5 b	520.1 b	461.0 b	362.0 b
Sakha 102	440.0 d	412.0 c	276.0 c	450.0 c	411.0 c	272.0 c
Straw (kg/fed.)						
Sakha 1	4884.0 a	3862.5 a	3614.5 bc	4890.0 a	3862.4 a	3602.3 bc
Sakha 2	4519.8 b	4107.5 a	3801.0 ab	4525.8 b	4101.1 a	3800.0 ab
Sakha 101	3788.0 c	3531.0 b	3456.0 c	3770.0 c	3526.0 b	3426.0 c
Sakha 102	4282.0 b	4004.0 a	3924.0 a	4262.0 b	4000.3 a	3902.0 a
Number of seeds/ plant						
Sakha 1	115.0 a	110.0 a	91.3 a	113.0 a	108.56 a	90.86 a
Sakha 2	78.5 b	74.8 c	63.0 c	79.1 b	75.10 c	62.45 c
Sakha 101	88.8 b	87.3 b	77.0 b	86.23 b	86.43 b	76.23 b
Sakha 102	87.0 b	82.8 bc	75.0 b	86.54 b	81.41 bc	74.56 b
Weight-1000 seed (gm)						
Sakha 1	6.6 a	5.01 b	3.48 bc	6.52 a	4.99 b	3.33 bc
Sakha 2	6.23 ab	5.20 ab	5.05 a	6.12 ab	5.13 ab	4.85a
Sakha 101	5.85 bc	5.43 a	3.65 b	5.76 bc	5.42 a	3.55 b
Sakha 102	5.75 bc	4.38 c	3.12 c	5.44 bc	4.23 c	3.06 c
Top capsule zone (cm)						
Sakha 1	22.25 a	21.75 a	16.25 b	21.86 a	21.45 a	16.04 b
Sakha 2	20.00 a	20.00 a	19.25 a	19.88 a	19.56 a	19.09 a
Sakha 101	19.75 a	18.75 a	17.26 a	19.76 a	18.60 a	17.12 a
Sakha 102	17.25 a	16.75 a	16.50 a	17.20 a	16.43 a	16.23a
Technical length(cm)						
Sakha 1	103.0 a	101.80 a	94.0 a	101.78 a	101.72 a	93.58 a
Sakha 2	99.50 a	97.50 b	91.0 b	98.76 a	96.45 b	90.55 b
Sakha 101	94.80 a	94.50 a	86.5 a	94.35 a	93.66 a	85.94 a
Sakha 102	98.30 a	101.3 a	79.0 a	97.87 a	101.22 a	78.96 a

Both fresh and blended water gave the highest straw yield of Sakha 1 and Sakha 2, while, irrigation of Sakha 102 with drainage water gave high straw yield in the two seasons without significant difference between all of them.

Irrespective of water quality, Sakha 1 gave the highest No. of seeds/plant in both seasons under all water qualities treatments.

Weight of 1000 seeds values in the second season confirm that in the first season where it took the same trend.

Little differences in top capsule zone and technical length were observed between flax varieties under all water quality treatments.

Heavy metals contents:

Data in Table (5) show that the studied heavy metals Cd, Pb, Ni and Cu contents of flax plant under drainage water were greater than that of fresh water and blended water. This could be attributed to the pollution sources of industrial (oil and soap factory) and municipal wastes discharged to the drainage system. These results are in agreement with those obtained by Zein *et al*. (2002) and El-Mowelhi *et al*. (1995). Also, Table, 5 illustrates the influence of different water qualities on the studied heavy metals concentration in straw and seeds of flax varieties. The order of heavy metals content in both seeds and straw was Cu> Pb > Ni > Cd.

Table (5): Effect of different water qualities on heavy metals content (mg/kg) of seeds and straw of flax varieties (mean of two seasons) and translocation coefficient (TC %)

Varieties	Heavy metals content (mg/kg plant dry weight)											
	Cu			Ni			Cd			pb		
	fresh water	Mixed water	Drainage water	fresh water	Mixed water	Drainage water	fresh water	Mixed water	Drainage water	fresh water	Mixed water	Drainage water
	Seeds											
Sakha 1	4.05 c	6.00 c	8.03 a	0.16 c	0.21 c	0.32 b	0.08	0.10	0.16	0.11 c	0.12 c	0.21 d
Sakha 2	4.40 b	6.10b c	8.03 a	0.17bc	0.22 bc	0.35 a	0.08	0.10	0.14	0.13 b	0.22 b	0.30c
Sakha 101	4.60 a	6.20 ab	8.10 a	0.18 ab	0.23 ab	0.35a	0.09	0.11	0.16	0.14 ab	0.26a	0.39 a
Sakha 102	4.70a	6.30 a	8.12 a	0.19a	0.24 a	0.36 a	0.10	0.13	0.18	0.15 a	0.23b	0.36 b
	Straw											
Sakha 1	11.0	22.0	23.0	2.30 d	4.31 d	4.36 b	1.03	2.03	3.05	3.62	5.71	6.82
Sakha 2	12.0	23.0	24.0	2.31 c	4.33 c	4.34 c	1.13	2.05	3.04	3.65	5.76	6. 86
Sakha 101	13.0	24.0	25.2	2.36 b	4.41 b	4.42 a	1.23	2.10	3.12	3.71	5.85	6.93
Sakha 10	14.0	24.5	25.3	2.40 a	4.41b	4.43 a	1.30	2.15	3.16	3.72	5.82	6.97
	Translocation from straw to seeds (%)											
Sakha 1	36.81	27.27	34.91	6.95	4.87	7.33	7.76	5.91	5.24	3.03	2.10	3.07
Sakha 2	36.66	26.52	33.45	7.35	5.08	8.06	5.30	4.78	4.61	3.56	3.76	4.37
Sakha 101	35.38	25.83	32.14	7.62	5.12	7.91	7.31	5.23	5.13	3.77	4.51	5.62
Sakha 10	33.57	25.71	32.09	7.91	5.44	8.12	7.69	6.04	5.70	4.03	3.93	5.16
Range *	**5-20**			**0.02-5**			**0.1-2.4**			**0.2-20**		

***Kabata Pendias and pedias (1992)**

Highly significant effects of water quality (fresh water, blended water and drainage water) were obtained especially with Cu, Ni and Pb.

The distribution of Cu within plants is highly variable within roots, meanwhile Cu is associated mainly with cell wall and it's largely immobile.

Duneman *et al*. (1991) found that the concentration of Ni in plants, generally, reflects the concentration of the element in the soil, although the relationship is clearly more directly related to the concentration of soluble ions of Ni and replenishment rate of this mobile pool. As Ni is easily mobile in plant, berries and seeds are reported to contain elevated Ni concentration (Kabata-Pendias*,* 2000).

Cadmium content of seeds had the lowest values in all studied heavy metals (Table 5). This conclusion is in agreement with that of Alloway (1995) who found that the uptake of Cd decreased when pH was increased. Page *et al.* (1981) found that relative excess of Cu, Ni and Mn can reduce uptake of Cd by plants. The Cd in plants is relatively very mobilize, although the translocation of Cd through the plant tissues may be restricted because Cd is easily held mainly in exchange sites of active compounds located in the cell walls (Cunningham *et al.*, 1975).

Data in Table (5) indicate that the flax seeds generally had the lowest content of studied heavy metals under all water qualities treatments. No significant difference in Cd for all treatments of water quality and flax varieties. Sakha 1 variety had the lowest content of Pb, Ni and Cu under all water quality treatments. Cadmium content in studied flax varieties decreased as follows: Sakha 2 < Sakha 1< Sakha 101 < Sakha 102, while the order was Sakha 1 < Sakha 2 < Sakha 101 < Sakha 102 for Pb, Cu and Ni. These results are very important for classified the more flax varieties tolerant to various heavy metals in polluted soils. From these sequences we can favor one variety in every soil polluted with one element. This may be due to the differences in genetic constitution of the studied genotypes and / or the dilution effect phenomenon. These results are in partial agreement with those obtained by Zein *et al*. (1996) in their study on soybean cultivars, and Shalaby *et al*. (1996) who concluded that increasing heavy metals concentration in plants may attributed either to the higher amounts of these heavy metals added into the used soil through the applied wastes.

Data of translocation coefficient from straw to seeds also were presented in Table (5). Once the ions have been absorbed through the roots and have been transferred to the xylem vessels, there is possibility of movement throughout the whole plant, the rate and extent of movement within plants was studied by, Alloway (1995).

The studied heavy metals translocation from straw to seeds can be arranged according to mean values of translocation coefficient in the following order:

Cu > Cd > Ni > Pb. Cupper had the largest values of TC % while Pb had the least in translocation from straw to seeds in all types of water treatments (fresh water, mixed water and drainage water). The results are in a good agreement with those of Zein *et al*. (2002) and Chaney and Giordano (1977) who classified Pb as one of the least translocated elements with plant. They added that, under conditions of optimal growth, Pb precipitates on root cell wall in the insoluble amorphous form. Zhen – Guo Shen *et al*., (2009) they found that application of EDTA (as an organic conditioner) to the soil significantly increased the concentrations of Pb and enhancing Pb accumulation in the plants while the Cu, Cd and Ni concentration and translocation coefficient indicate that Ni values increased due to drainage water treatment than other treatments due to its higher content of polluted drainage water from oil and soap factory (used Ni as a catalyst in one processes of manufacturing). The obtained results are in a good agreement with those of Chancy and Giordano (1977) and Zein *et al*., (2012) for heavy metal translocation**.**

CONCLUSION

Considering the previous discussions, it seems that there is an obvious need for more research work to be carried out on the risk assessment of heavy metals contaminated soils. As mentioned by Eissa and El-Kassas (1999) the danger of distribution wastes by such factories containing high concentration of heavy metals affects the survival in the suffering areas. The safest policy would appear to minimize inputs of heavy metals to soil wherever to save our life and economy and restrict heavy metals bioavailability in the soil- plant- animal pathway. Abo El-Naga *et al*. (1999) and Zein *et al*. (1998 and 2009) recommended that attention must be earnestly given to protect the environment and commitments and the latest law issued 1994 in Egypt, must be obligatory undertaken for these factories to prevent them from polluting agricultural land by wastes. They added that apart from the roles played by pollution control and soil chemistry, plant breading can make a vital contribution through the selection and utilization of crop genotypes which accumulate the least of heavy metals.

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خواص التربة وإنتاجية أصناف الكتان ومحتواهما من العناصر الثقيلة تحت الري بمياه منخفضة الجودة

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**** قسم استخدامات التربة والمياة المركز القومى للبحوث -مصر**

أقيمت تجربتين بمحطة البحوث الزراعية بسخا – كفر الشيخ – مصر لموسمى2011 /2012 و2013/2012 لدراسة تأثير نوعية مياه الري على إنتاجية أربعة أصناف من الكتان هي سخا 1 وسخا 2 وسخا 101وسخا 102على خواص التربة الكيمائية وكذلك على محتوى التربة وأجزاء النبات من العناصر الثقيلة وهى النحاس الرصاص والكادميوم، النيكل . وقد أجريت الدراسة في ليسميترات (100 × 70 × 90 سم) بها تربة طينية وتروى الليسميترات بثلاثة نوعيات من مياه الري وهذه النوعيات هي مياه عزب (مياه ذات نوعية جيده) و مياه صرف (ذات نوعية رديئة) ومياه مخلوطة (50 % مياه النيل + 50% مياه صرف) ووضعت المعاملات في قطع منشقة في أربع مكررات حيث وضعت نوعية مياه الري في القطع الرئيسية والأصناف في القطع الشقية.

وأوضحت النتائج ما يلي :

- زاد استخدام مياه الصرف في الري من قيم التوصيل الكهربي ECe ، والكاتيونات والأنيونات الذائبة في مستخلص عجينة التربة المشبعة وكذلك محتوى التربة المستخلص ب DTPA من العناصر الثقيلة بالمقارنة بالمياه المخلوطة أو مياه النيل في الري .
- وجد أن هناك تأثير عالي المعنوية لنوعية المياه المستخدمة في الري على المحصول ومكونات المحصول وكذلك محتوى بعض أصناف الكتان من العناصر الثقيلة المدروسة.
- كان محتوى أجزاء النبات من العناصر الثقيلة تبع الترتيب القش> البذور.
- أوضحت النتائج أن صنف سخا 1 كان أكثر الأصناف تحملا لاستخدام المياه المخلوطة، ومياه الصرف وكان الأقل في محتواه من الرصاص ، النيكل، النحاس ولا يوجد هناك فروق معنوية مع عنصر الكادميوم لكل الأصناف تحت الدراسة .
- أظهرت النتائج أن قلة محتوى الأصناف من العناصر الثقيلة أخذ الترتيب التالي:
  مع الكادميوم: سخا 2< سخا 1< سخا 101< سخا 102
  ومع الرصاص: سخا 1< سخا 2< سخا 101< سخا 102
  ومع النيكل: سخا 1< سخا 2< سخا 101< سخا 102
  ومع النحاس: سخا 1< سخا 2< سخا 101< سخا 102
- سجلت كل الأصناف التي تم دراستها درجة مقاومة لملوحة مياه الري المخلوطة في المحصول ومكوناته وعليه يمكن التوصية بزراعة أي منها بالمناطق التي تستخدم المياه المخلوطة في الري. أتضح أن العناصر الثقيلة المدروسة وهى النيكل والرصاص والكادميوم والنحاس تتراكم في نبات الكتان بكميات كبيرة وهذا يجعله أن يكون مؤشر مفيد للدلالة على مدى جاهزية العناصر في الأراضي الملوثة بالعناصر الثقيلة ويمكن أستخدامة في استخلاص هذه العناصر من الأراضي الملوثة بها.