Australian Journal of Basic and Applied Sciences, 6(7): 611-616, 2012
ISSN 1991-8178

Response of Castor Bean Plants to Potassium Foliar Application and Treated Sewage Water

[1]Hussien, M.M., [2]A.I. Rezk, [1]H.M. Mehanna and [2]A. B. El-Nasharty

[1]Water Relations & Irrigation and [2]Fertilization Technology Dept., Agric. & Bio Division, National Research Centre, Cairo, Egypt

Abstract: A pot experiment was conducted in a greenhouse during two summer seasons (2010 and 2011) to evaluate the concentration of macro and micro-nutrients in shoots of castor bean plants and the effect of using treated sewage water as an irrigation source on the growth of castor bean plants. The treatments were: 1. Irrigation by treated sewage water with primary and secondary treatment and tap water as a control and 2. Spray potassium sulfate in rate of 1 %. Results indicated that considerable increases in stem and whole plant dry weights were shown as irrigation castor bean plants by using primary or secondary treated sewage water as a nontraditional irrigation source but the highest values were obtained by using primary treated sewage water than that by secondary treated sewage water. Potassium spray enhanced the most growth character of plants irrigated with tap or treated effluent water in different ratios. The increases in stem and total dry weight of irrigating plants with primary treated sewage water were more than when secondary treated water or tap water was used. In spite of the highly effect of potassium on leaves dry weight of plants irrigated by primary treated water, this parameter slightly affected under secondary treated water. However, response to potassium treatment was similarly with both type of treated water, except of number of leaves per plant and root dry weight was non-significantly responded. The highest values of Zn, Fe and K concentrations were obtained by spraying castor beans plants with foliar of 1% potassium sulfate and irrigation by primary treated sewage water. Zn, Mn, Fe, Mg and Ca contents responded significantly to potassium foliar application in the rate of 1% under irrigation by different type of used water, except for Na and K contents. Moreover, the increment obtained by spraying castor bean plants with potassium sulfate under irrigation by primary treated sewage water were more than irrigation by secondary treated sewage water as well as tap water. Generally, the use of primary and secondary effluent in irrigation process can improve castor bean plant growth because they are considered as natural conditioners through their contents from nutrients elements and organic matter which will be affect the growth characters of plants. Also spraying plants by potassium foliar reduce the stress of treated sewage water on plants.

Key words: Castor bean, Irrigation, Treated sewage water, Potassium foliar application, Mineral status.

INTRODUCTION

Water shortage is a problem of high concern in the Mediterranean Basin (Hochstrat, *et al.* 2006). Taking into account the scarcity of conventional water sources, due to water demand increases linked to population growth and to agricultural water usage (< 80% of total water consumption), there is an urgent need to make available alternative water sources for agriculture replacing the high-quality water required for human consumption (Toze, 2006). In reality, waste water is considered as an enormous nutrient source for irrigated plant, (Rattan, *et al*. 2005).

In Egypt, sewage effluent has been used in irrigation since 1941's in a desert sandy area northeast of Cairo. At present, small scattered plots are also irrigated with sewage effluent. A national project for re-using sewage effluent in growing forests are about to arise. Sewage effluent generated from sewer stations in both lower and Upper Egypt, raw or treated,

Falls in a good permissible range for most crops according to their salinity and heavy metal contents. In addition, their high nitrogen and other nutrient elements content significantly reduce or even exterminate the exigency for chemical fertilizers (Hussein, *et al.* 2004). Wastewater is a preferred marginal water source, since its supply is reliable and uniform. Costs of this water source are low compared with those of other nonconventional irrigation water sources (e.g. desalinization) since agricultural reuse of urban wastewater serves also to dispose of treated urban sewage water (Haruvy & Sadan, 1994).

Foliar fertilization is the most efficient way to increase yield and plant health. Tests have shown that foliar feeding can increases yields from 12% to 25% when compared to conventional fertilization. Tests, conducted in different locations, under different environmental conditions, have reflected the following; when fertilizers are

Corresponding Author: H.M. Mehanna, Water Relations & Field Irrigation Department National Research Centre, Cairo, Egypt
E-mail: mr.mehana@gmail.com

foliar applied, more than 90% of the fertilizer is utilized by the plant. When a similar amount is applied to the soil, only 10 percent of it is utilized. In the sandy loam soils, foliar applied fertilizers are up to 20 times more effective when compared to soil applied fertilizers. Foliar feeding is an effective method for correcting soil deficiencies and overcoming the soil's inability to transfer nutrients to the plant under low moisture conditions (Marchener, 1995 and Stigler, *et al*. 2010).

Potassium fertilizer was found to be important for potato plant growth, yield and its quality (Abo-Hussein. 1995 and Habib, *et al.*, 2011). In the same respect, Yildirim, *et al.* (2009) found that foliar application of potassium nitrate (KNO_3) resulted in increasing plant dry weight and leaf mineral content and improved early fruit yield and quality. On the other hand, Lanauskas, *et al.* (2006) indicated that the favorable effect of potassium fertilizer on plant growth may be due to that potassium element is very important in the overall metabolism of plant. In addition, it has a beneficial effect on water consumption. In the same respect, potassium involved in a number of steps in protein synthesis. whereas, potassium is the prevalent action in plant and involved in maintenance of ionic balance in cells and it bounds ionically to the enzyme pyruvate kinase, which is essential in respiration and carbohydrates metabolism (Marchener, 1995).

Several researches were conducted in the relations between potassium fertilization and salinity and concluded that potassium enhancing the salt tolerance in plants (Hussein, *et al.* 2010-a, Hussein, *et al*. 2010-b and kaya, *et al.* 2007).

Study of displayed that all growth parameters measured in *P. eldarica* trees were statistically greater in effluent-irrigated area than in well-watered area. As a whole, the use of municipal effluent in irrigations can be an overflowing resource from the nutrient elements required for plants (Mapanda *et al*., 2005 and Toze, 2006). As a matter of fact, high nutrient concentrations in effluent, compared to those in well water cause the nutrient accumulation in the soil (Emongor and Ramolemana, 2004) and makes easy the access of plants to the high nutrient concentrations (macro and micro elements) and increases their growth. Ostos, *et al*. (2007) on *Pistacia lentiscus*, show that faster growth of tree occurs in the effluent-irrigated areas. This is mostly due to high nutrient concentration in effluent. It may be also noted that the nutrient contents in the municipal effluent is more than needed by plants whereas in the such conditions trees can produce greater biomass (Singh and Bhati, 2005 and Guo *et al*., 2006).

Ali *et al.* (2011) noticed that the primary effluent treatment was superior than other treatments in improving the growth parameters (plant height, stem diameter, leaf area, leaves number, fresh and dry weights of leaves, shoots and roots and shoot/root ratio), followed by secondary effluent then tap water.

Singh and Bhati (2005) and Aghabarati, *et al.* (2008), reported that a substantially greater above-mentioned minerals concentration were observed in leaf of *Dalbergia sissoo* seedlings and *Olea europaea* trees irrigated with municipal waste water compared to control. However, had also suggested that a decrease of Mg and Ca, and no difference of Na concentration in leaf of eucalypt and olive tree which treated by municipal waste water. In fact, quantity of nutrients absorption by plant depends upon the total quantity of the nutrients applied through waste water application, soil properties and type of plant (Bozkurt and Yarilga, 2003). The minerals concentration of needle may be ranked from greatest to least as N > Ca > K > Mg > P > Na. Their results suggested that the use of sewage effluent in irrigating mahogany trees grown on calcareous sandy loam soil was an important agriculture practice for improving soil properties, increasing fuel and timber production and have an economic and safe way to dispose waste waters. This study aims to investigate the response of castor bean plants to irrigate with treated sewage water and potassium foliar application.

MATERIALS AND METHODS

A pot experiment was conducted in a greenhouse during two summer seasons (2010 and 2011) to evaluate the concentration of macro and micro-nutrients in shoots of castor bean plants irrigated with treated sewage water the treatments were as follows:

1. Irrigation by effluent sewage water with primary and secondary treatment and tap water as control.
2. Spraying 1% potassium sulfate and tap water as control.

Primary treatment of sewage water*:* This is a simple sedimentation process in which organic and inorganic solids are allowed to settle and removed from the water. This action reduces the biological oxygen demand by 25 to 50 percent, the total suspended solids from 50 to 70 percent and the oil and grease content by 55 to 65 percent. Some organic nitrogen, phosphorus and heavy metals are also removed (FAO, 1992).

Secondary treatment of sewage water*:* This method consists of further processing (after the primary treatment) to remove the rest of the organic matter and suspended solids using biological processes (i.e. metabolism by aerobic micro-organisms, mainly bacteria). Secondary treatment is required when the risk of public exposure to waste water is high (e.g. in the case of food crops). It is also required in many industrialized countries to prevent environmental pollution. Much of the nitrogen and phosphorus remains after such treatment, however, and if the effluent is discharged into water bodies with an insufficient diluting capacity it may lead to water pollution (FAO, 1992). Table (1) shows the analysis of the primary and the secondary treated waste water.

Table 1: Analysis of irrigation water used in the experiment.

Source of treated sewage water	pH	EC dSm^{-1}	Soluble cations (meq/l)				Soluble anions(meq/l)			
			Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	CO^{-3}	HCO^{-3}	Cl^{-1}	SO^{-2}
Primary	7.25	1.6	5.70	0.92	3.76	4.0	0.01	4.6	5.3	4.47
Secondary	7.05	1.5	6.04	0.97	3.69	4.2	0.01	4.8	5.7	4.39

Table (2) shows the physical and chemical analysis of soil.

Table 2: Soil physical and chemical analysis **.**

Texture	pH 1:2.5	EC dSm^{-1} 1:5	$CaCO_3$ %	CEC C mole Kg^{-1}	OM %	Soluble cations and anions (meq/100 g soil)						
						Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	HCO^{-3}	Cl^{-1}	SO^{-2}
Clay	7.15	0.60	2.53	33.5	1.3	1.82	0.23	2.38	1.27	0.91	1.9	2.94

Available macro-nutrients (meq/100 g soil)			Available micro-nutrients (ppm)			
N	P	K	Zn	Fe	Mn	Cu
0.47	0.25	0.95	3.1	4.8	7.3	5.2

The experiment included three irrigation treatments in combination with 2 potassium foliar fertilize (6 treatments) in 6 replicates. Pots 35 cm in diameter and 50 cm in depth were used. Every pot contained 30 Kg of air dried clay soil.

Seeds of caster bean *(Ricinis communis L.)* were sown in 1st July in two summer seasons (2010 and 2011) plants were thinned twice, the 1st two weeks after sowing and the 2nd two weeks latter to leave three plants per pot. 3.0g calcium super phosphate (15.5% P_2O_5) and 1.5g potassium sulfate (50% K_2O) per pot were added before sowing. Ammonium sulfate (20.5% N) in the rate of 6.86 g/pot was added in two equal portions, the 1st two weeks after sowing and the 2nd two weeks latter. Irrigating with treated sewage water were started 30 days after sowing, one irrigation by sewage water followed by irrigating by tap water alternatively. Potassium was sprayed twice, 21 and 36 days after sowing.

Samples were collected, cleaned, oven dried at 70 C^{o} and ground in a stainless steal mill. Digestion and determination of minerals were done using the methods described by Cottenie *et al*. (1982).

The collected data were subjected to the proper statistical analysis with the methods described by Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

Growth:

Data illustrated in Table (3) show the effect of irrigation water source on the growth parameters of castor plants. Considerable increases in stem and whole plant dry weights were shown as irrigation castor bean plants by primary or secondary treated sewage water but the increases obtained by primary were more than that obtained from secondary treated sewage water (Table 3). However, the increases in plant height, number of leaves, dry weights of roots and leaves per plant, and dry weight of whole plant were not enough to reach the level of significance. Plant height was increased by 7.7% and 4.7% by using primary and secondary treated sewage water comparing with tap water, respectively. The same trend was obtained for dry weights of stem, leaves and whole plant, except for number of leaves per plant where there is no difference by using tap water or primary treated sewage water as an irrigation source for castor bean plants. Generally, the highest values of dry weight of whole plant were gained from irrigating plants with primary treated sewage water followed by irrigating with secondary treated sewage water comparing with irrigating with tap water. The increases of the last discussed parameter is very clear, where it increased by 56.81% and 27.46% for primary and secondary treated sewage water comparing with tap water, respectively.

Table 3: The effect of treated sewage water on the growth parameters of castor plants (average of two seasons 2010 and 2011).

Water type	Plant height (cm)	Dry weight of stem (g)	Dry weight of root (g)	Dry weight of leaves (g)	Dry weight of whole plant (g)	Number of leaves/plant
Primary treated sewage	105.00	11.47^{a}	0.482	3.81	15.76	5.88
Secondary treated sewage	102.13	8.69^{ab}	0.484	3.62	12.81	5.38
Tap (control)	97.50	6.42^{b}	0.476	3.15	10.05	5.88
L.S.D. at 5% level	N.S.	4.80	N.S.	N.S.	N.S.	N.S.

Positive effect was detected in plant height, number of leaves/plant and stem, leaves and whole plant dry weights of castor bean was obtained by foliar spray of potassium fertilizer. The highest increment was shown in dry weight of stem/plant (89.7%) followed by those of dry weight of whole plant (80.8 %) as well as those of dry weight of leaves (74.7 %) (Table, 4).

Table 4: The effect of Potassium foliar application on the growth parameters of castor plants (average of two seasons 2010 and 2011).

Potassium foliar treatments	Plant height (cm)	Dry weight of stem (g)	Dry weight of root (g)	Dry weight of leaves (g)	Dry weight of whole plant (g)	Number of leaves/plant
control	92.17[b]	6.12[b]	0.476	2.57[b]	9.17[b]	5.19
1%	110.92[a]	11.61[a]	0.486	4.49[a]	16.58[a]	5.50
L.S.D. at 5% level	11.46	4.13	N.S.	1.95	5.51	N.S.

The interactive effect of potassium foliar application and irrigation by treated sewage water on growth characters were presented in Table (5).This Data showed that plants irrigated with tap or treated effluent water and potassium spray enhanced the most growth character in different ratios. The increases in stem and total dry weight of irrigating plants with primary treated sewage water were more than when secondary treated water or tap water was used. In spite of the highly effect of potassium on leaves dry weight of plants irrigated by primary treated water, this parameter slightly affected under secondary treated water. However, response to potassium treatment was similarly with both type of treated water, except of number of leaves per plant and root dry weight which was non-significantly responded.

Use of waste water are creates opportunities for commercial biomass production and sequestration of excess minerals in the plant system (Sharma and Ashwath, 2006). Therefore, the use of waste water in growing woodlots is a viable option for the economic disposal of waste water (Neilson *et al.*, 1989). Khan, *et al.* (2010) shows that plant height of sorghum was significantly greater in treated effluent application compared to fresh water or fresh water with basal fertilizer. However, no significant variation was recorded in leaf area index. These results are agree with Mapanda *et al*., (2005) and Toze (2006) on *P. eldarica* trees, Ostos, *et al*. (2007) on *Pistacia lentiscus*, Singh and Bhati (2005) on *Dalbergia sissoo*; and Guo *et al*. (2006) on Eucalyptus.

As a matter of fact, high nutrient concentrations in effluent, compared to those in well water cause nutrient accumulation in the soil and makes easy the access of plants to the high nutrient concentrations (macro and micro elements) and increases their growth and fertility faster growth of tree occurs in the effluent-irrigated areas (Emongor and Ramolemana,2004). This is mostly due to high nutrient concentration in effluent. Ali *et al.* (2011) noticed that the primary effluent treatment was superior than other treatments in improving the growth parameters (plant height, stem diameter, leaf area, leaves number, fresh and dry weights of leaves, shoots and roots and shoot/root ratio), followed by secondary effluent than tap water. Moreover Taiz and Zeiger (1991) indicated that potassium is an essential nutrient and an integral component of several important compounds in plant cells. This attributed to the role of K in biochemical pathways in plants, where K acts as an activator for several enzymes involved in carbohydrates metabolism (Taiz and Zeiger, 1991).

Table 5: The effect of the interaction between treated sewage water and spray by potassium fertilizer on the growth parameters of castor plants (average of two seasons 2010 and 2011).

Water type	Potassium foliar treatments (%)	Plant height (cm)	Dry weight of stem (g)	Dry weight of root (g)	Dry weight of leaves (g)	Dry weight of whole plant (g)	Number of leaves/plant
Primary treated sewage	control	96.25a[bc]	7.06[b]	0.485	2.53[b]	10.08[b]	5.75
	1 %	113.75[a]	15.88[a]	0.480	8.05[a]	21.43[a]	6.00
Secondary treated sewage	control	93.50[bc]	6.71[b]	0.480	3.18[ab]	10.37[b]	5.20
	1 %	110.75[ab]	10.69[ab]	0.487	4.07[ab]	15.24[ab]	5.50
Tap (control)	control	86.75[c]	4.58[b]	0.462	1.99[b]	7.04[b]	5.50
	1 %	108.25[ab]	8.26[b]	0.490	4.31[ab]	13.07[ab]	6.25
L.S.D. at 5% level		19.85	7.15	N.S.	3.00	9.54	N.S.

Mineral Status:

Table (6) shows the effect of irrigation by treated sewage water and potassium foliar spray on the concentration of minerals in leaves of castor bean plants. Data indicated that Zn, Fe, and K affected significantly by experimental treatments comparing with control, where the aforementioned minerals increased by foliar application of potassium sulfate under the three irrigation water type treatments. Nevertheless, the differences between other determined macro and micronutrients concentrations values were not significant. The highest values of Zn, Fe and K concentrations were obtained by spraying castor beans plants with 1% potassium sulfate and irrigation by primary treated sewage water. Increases in minerals concentration may have been due to the effect of nutrients addition through municipal waste water (Meli, *et al.* 2002).

Table 6: Effect of potassium foliar spray and irrigation by treated sewage water on the concentration of nutrients in leaves of castor bean plants.

Water type	K treatments	(ppm)			(%)			
		Zn	Mn	Fe	Mg	Ca	Na	K
Primary treated sewage	Control	94.50^{ab}	150.00	261.75^{ab}	0.910	4.68	0.345	3.950^{ab}
	1 %	109.25^{a}	161.50	323.00^{a}	0.972	5.03	0.380	4.275^{a}
Secondary treated sewage	Control	79.25^{bc}	153.00	241.50^{ab}	0.875	4.38	0.340	3.750^{ab}
	1 %	83.00^{bc}	153.00	250.25a^{b}	0.942	4.83	0.358	4.150^{ab}
Tap (control)	Control	66.25^{c}	137.75	164.00^{b}	0.898	4.18	0.335	3.450^{b}
	1 %	72.25^{bc}	143.50	218.50^{ab}	0.935	4.28	0.345	3.775^{ab}
L.S.D. at 5% level		24.49	N.S.	131.6	N.S.	N.S.	N.S.	0.720

Data illustrated in Table (7) shows the effect of potassium foliar spray and irrigation by treated sewage water on the content of nutrients in leaves of castor beans plants. From Table (7), it is clear that all macro and micronutrients are affected significantly, except for Na and K contents. Zn, Mn, Fe, Mg, Ca, Na, and K contents were responded to potassium foliar application under irrigation by different type of used water. The increment of Zn content amounted by 131.09%, 23.37% and 145.24% as foliar application with potassium sulfate comparing with control under irrigation by primary and secondary treated water, and tap water, respectively. Moreover, the increment obtained by spraying castor bean plants with 1% potassium sulfate under irrigation by primary treated sewage water were more than irrigation by secondary treated sewage water as well as tap water.

Generally, the use of primary and secondary effluent in irrigation process can improve growth of castor bean plant because they are considered as natural conditioners through their contents of nutrients elements and organic matter which will be effect the productivity of plants. Also spraying plants by potassium sulfate reduce the stress of treated sewage water on plants.

These results are in agreement with Emongor and Ramolemana (2004), Bozkurt and Yarilga (2003), Singh and Bhati (2005), Aghabarati, *et al*. (2008) and Ali *et al*. (2011) who revealed that the primary effluent treatment was superior than other treatments and showed the highest concentration and total uptake of N, P, K, Cd, Ni, Pb and Fe in plant parts, followed by secondary effluent then tap water. This clear for this study in Table (1), which shows the analysis of the two types of used treated sewage water in irrigation process.

Table 7: Effect of potassium foliar spray and irrigation by treated sewage water on the content of nutrients in leaves of castor bean plants.

Water type	K treatments	ug/plant			mg/plant			
		Zn	Mn	Fe	Mg	Ca	Na	K
Primary treated sewage	Control	0.238^{b}	0.378^{b}	0.655^{b}	0.023^{bc}	0.119^{b}	0.009	0.109
	1 %	0.550^{a}	0.826^{a}	1.761^{a}	0.051^{a}	0.255^{a}	0.020	0.194
Secondary treated sewage	Control	0.261^{b}	0.480^{ab}	0.799^{ab}	0.027^{bc}	0.133^{ab}	0.010	0.124
	1 %	0.322^{ab}	0.615a^{b}	0.990^{ab}	0.041^{ab}	0.186^{ab}	0.014	0.149
Tap (control)	Control	0.126^{b}	0.246^{b}	0.308^{b}	0.017^{c}	0.087^{b}	0.007	0.074
	1 %	0.309^{ab}	0.583^{ab}	0.879^{ab}	0.041^{ab}	0.180^{ab}	0.015	0.184
L.S.D. at 5% level		0.233	0.390	0.964	0.021	0.116	N.S.	N.S.

Conclusion:

There were considerable increases in dry weights of stem, leaves and whole plant as irrigation castor bean plants by primary or secondary treated sewage water as an irrigation source, especially when plants are sprayed by 1% potassium sulfate, but the highest values were obtained by using primary treated sewage water than that by secondary treated sewage water under the foliar of potassium sulfate treatment. The same trend was obtained for plant height, number of leaves and dry weight, which will be effect the productivity of plants. K, Mn and Zn concentrations affected significantly by treated sewage water. Generally, use of primary and secondary effluent in irrigation process can improve castor bean plant growth because they are considered as natural conditioners through their contents of nutrients elements and organic matter which will be affect the productivity of plants. Also spraying plants by potassium sulfate reduce the stress of treated sewage water on plants, for that it should be spray plants by K fertilizer.

REFERENCES

Abo-Hussein, S.D., 1995. Studies on potato fertigation in newly reclaimed land. M. Sc.Thesis, Hort. Dept. Fac. of Agric. Ain Shams Univ. Cairo, Egypt.

Aghabarati, A., S.M. Hosseni, A. Esmaeili and H. Maralian, 2008. Growth and mineral accumulation in *Olea europaea* L. trees irrigated with municipal effluent. Res. J. Environ. Sci., 2(4): 281-290.

Ali, H.M., S.M. EL-Mahrouk, F.A. Hassan and M.A. EL-Tarawy, 2011. Usage of sewage effluent in irrigation of some woody tree seedlings. Part 3: *Swietenia mahagoni* (L.) Jacq. Original Research Article. Saudi Journal of Biological Sciences, 18(2): 201-207.

Bozkurt, M.A. and T. Yarilga, 2003. The effects of waste water sludge applications on the yield, growth, nutrition and heavy metal accumulation in apple trees growing in dry conditions. Turk. J. Agric. For, 27: 285-292.

Cottenie, A., M. Verloo, L. Kiekense, G. Velghe and R. Camerlynck, 1982. Chemical analysis of plants and soils handbook. Gent, Germany: State University of Belgium.

Emongor, V.E. and G.M. Ramolemana, 2004. Treated sewage effluent (water) potential to be used for horticultural production in Botswana. Original Research Article. Physics and Chemistry of the Earth, Parts A/B/C, 29(15-18): 1101-1108.

FAO, 1992. Wastewater treatment and use in agriculture. FAO irrigation and drainage paper 47. http://www.fao.org/docrep/T0551E/T0551E00.htm.

Guo, L.B., R.E.H. Sims and D.J. Horne, 2006. Biomass production and nutrient cycling in Eucalyptus short rotation energy forests in New Zealand: II. Litter fall and nutrient return. Biomass and Bioenergy, 30: 393-404.

Habib, H., M.R. Shafeek, M.F. Zaki and Z.S. El-Shal, 2011. Response of potato plants (*Solanum tuberosum L.*) to foliar application with different sources of potassium**.** Inter J. of Acad. Res., 3(3) Part 1.

Haruvy, N. and E. Sadan, 1994. Cost benefit analysis of wastewater treatment in the water scarce economy of Israel: a case study. J. Financial Management and Analysis, 7(1): 44-51.

Hochstrat, R., T. Wintgens, T. Melin and P. Jeffrey, 2006. Assessing the European wastewater reclamation and reuse potential—a scenario analysis. Desalination, 188: 1-8.

Hussein, H.F., M.S. Saber, S.M. Radwan and M. Abu-Seda, 2004. Use of treated domestic sewage effluent for growing summer oil crops in arid lands. International Conf. on Water Resources & Arid Environment.

Hussein, M.M., A.A. Abdel-Kader, K.A. Kady, R.A.Youssef and A.K. Alva, 2010-a. Sorghum response to foliar application of phosphorus and potassium with saline water irrigation, Journal of Crop Improvement, 24(4): 324-336.

Hussein, M.M., M.M. Shaaban and A.M. El-Saady, 2010-b. Response of cowpea plants grown under salinity stress to PK-foliar application. American J. of Plant Physiol., 3(2): 81-88.

Kaya, C., A.L. Tuna, M. Ashraf and H. Altunlu, 2007. Improved salt tolerance of melon (*Cucumis Melo L.)* by the addition of proline and potassium nitrate. Environmental and Experimental Botany, 60: 397-403.

Khan, M.A., S.S. Shaukat, O. Hany and S. Jabeen, 2010. Irrigation of sorghum crop with waste stabilization pond effluent: Growth and yield responses. Pak. J. Bot., 42(3): 1665-1674.

Lanauskas, J.N., A.U. Valiuskaite and P. Viskelis, 2006. Effect of foliar and soil applied fertilizers on strawberry healthiness, yield and berry quality. Argon. Res., 4: 247-250.

Mapanda, F., E.N. Mangwayana, J. Nyamangara and K.E. Giller, 2005. The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. Agriculture, Ecosystems and Environment, 107: 151-165.

Marchener, H., 1995. Mineral Nutrition of Higher Plants. New York: Academic Press.

Meli, S., M. Porto, A. Bellingo, S.A. Bufo, A. Mazzatura and A. Scopa, 2002. Influence of irrigation with lagooned urban wastewater on chemical and microbiological soil parameters in a citrus orchard under Mediterranean condition. Sci. Total Environ., 285: 69-77.

Neilson, G.H., D.S. Stevenson, J.J. Fitzpatrick and C.H. Brownlee, 1989. Nutrition and young apple trees irrigated with municipal waste water. J. Am. Soc Hortic. Sci., 114: 377-383.

Ostos, J.C., R.L. Pez-Garrido, J.M. Murillo and R. Lo´pez, 2007. Substitution of peat for municipal solid waste- and sewage sludge-based composts in nursery growing media: Effects on growth and nutrition of the native shrub Pistacia lentiscus L. Bioresource Technology.

Rattan, R.K., S.P. Datta, P.K. Chhonkar, K. Suribabu and A.K. Singh, 2005. Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater a case study. Agriculture, Ecosystems & Environment, 109(3-4), 1: 310-322.

Sharma, A. and N. Ashwath, 2006. Land disposal of municipal effluents: Importance of choosing agro-forestry systems. Desalination, 187: 361-374.

Singh, G. and M. Bhati, 2005. Growth of *Dalbergia sissoo* in desert regions of western India using municipal effluent and the subsequent changes in soil and plant chemistry. Bioresour. Technol., 96: 1019-1028.

Snedecor, G.W. and W.G. Cochran, 1990. Statistical Methods. 8th Ed., Iowa State Univ., Press, Iowa, U.S.A.

Stigler, J.C., L.D. Michaem, R. Ichrdson, E. Dougjas, A. Karcher and J. Patton, 2010. Foliar nutrient uptake by cool-season and warm-season turf grasses. University of Arkansas research lends insight into understanding turf grass foliar feeding. USGA Sponsored Research You Can Use. turf.lib.msu.edu/gsr/2010s/2010/100107.

Taiz, L. and E. Zeiger, 1991. Plant Physiology, mineral nutrition. The Benjamin Cummings Publishing Co., Inc. Redwood City, CA.

Toze, S., 2006. Reuse of effluent water-benefits and risks. Agric. Water Manage, 80: 147-159.

Yildirim, E., H. Karlidag and M. Turan, 2009. Mitigation of a salt stress in strawberry by foliar K, Ca and Mg nutrient supply. Plant, Soil and Environment, 55(5): 213 -221.