Journal of Genetic and Environmental Resources Conservation, 2013,1(3):276-286.
www.jgerc.com

The potential for irrigating jatropha with industrial drainage water under mineral fertilization

El-Ashry S.M. [1], Hussein M.M.[2] and Nesreen H. Abou-Baker[1]
[1]Soil and Water Resources Dept. and [2]Water Relations and Irrigation Dept., National Research Center, Giza, Egypt.

Abstract

Irrigation water shortage is considered one of the limiting factors affect the extension of new cultivating areas towards the desert. In addition to, Jatropha (*Jatropha curcas* L.) fertilization has yet not been well studied. Therefore, this study focuses on using low quality water in irrigation of jatropha plant under different rates of combined fertilizer. A pot experiment was undertaken in the greenhouse of the National Research Center, Dokki, Giza, Egypt using three rates of NPK fertilization ($N_0P_0K_0$, $N_3P_3K_3$ and $N_6P_6K_6$) and irrigation by four mixtures of industrial drainage water (S_0= 0 IDW + 100% fresh water, S_1 = 25% IDW + 75% fresh water, S_2 = 50% IDW + 50% fresh water and S_3 = 75% IDW + 25% fresh water) on mineral concentration and content of jatropha plants. Leaves dry weight responded negatively with increasing IDW percentage and positively to the application of combined fertilizer. Treatment of 75% mixed drainage water lowered the concentration of macronutrients more than the other mixed water. The highest depression was shown in N and P concentrations. A negative relationship was observed between the increase of drainage water percentage in irrigation water and nutrients content. All nutrients content increased significantly by addition of combined fertilizer in its both rates compared to control ($N_0P_0K_0$). Reduction in K:Na ratio under S_2 treatment was observed, while, Ca:(K+Na) ratio was increased gradually with increasing IDW percentage. Combined fertilizer application improved the K:Na in parallel to the increase of fertilizer rate but depressed Ca:Na and Ca:(Na+K) ratios. Application of $N_6P_6K_6$ could be beneficial for improved plant ability to survival with abiotic stress like irrigation with low quality water.

Keywords: Jatropha, Drainage water, Industrial, NPK fertilizers, Nutrient.

Introduction

Because of growing demand for fresh water supply with increasing energy prices and depletion of water sources, farmers are forced to use efficient irrigation systems and/or to consider water stress practices or deficit irrigation to alleviate water shortage. Therefore, many attempts have been made to us the nontraditional water resources such as agriculture and industrial drainage water and sewage water in new or contaminated soils (Jamil *et al.,* 2009). Many objections for use of these types of water particularly its contents of heavy metals beside the contamination with pasogenic micro-organisms. Thus, several investigators suggested the use of these nontraditional water resources in biofuel crops production. Yet consequently, brackish water or recycled wastewater can be used for irrigation, minimizing the exploitation of natural water resources (Bedbabis *et al.*, 2010). Industrial drainage water is considered one from the non-conventional resource of water can use in growing bio-fuel crops (Farook *et al.*, 2006; Glenn *et al.*, 2009; Bedbabis *et al.*, 2010)

Energy availability and energy use are issues of global concern and have been under research worldwide for a long time. Attention is mostly given to reduce energy consumption and to detect new and renewable energy resources, in order to cope with the world energy crisis. Two main processes are responsible for this situation: first, the increasing population and development rates are rapidly multiplying the global energy demand in many countries; secondly, the great share that traditional fossil fuels occupy on the global energy consumption can hardly be sustained. In fact, the ongoing fossil fuels depletion has reached a stage where the current reserves seem not enough for future needs. Furthermore, the role of fossil fuels on climate change and global warming can no longer be neglected (Da Schio, 2010).

Jatropha (*Jatropha curcas* L.) has fruits contains a considerable content of oil and survive the heavy metals and can grow under adverse environmental conditions which raise the possibility to use it in production of biofuel under irrigation by poor quality water (World Agro-forestry Centre, 2007 and Trabucco *et al.*, 2010) and also can grow in contaminated soils (Jamil *et al.,* 2009). Different Fertilization of urban trees is one cultural practice that lacks substantial research and tends to be governed by traditional forestry objectives and rule of thumb (Harris, 1992). While traditional Forestry and Pomology have used addition of nutrients to maximize growth, size, fiber and fruit yield of trees, arboriculturists are more apt to fertilize trees to ameliorate nutrient deficiencies.

Lack of water and inadequate soil volumes are responsible for many of the problems that beset urban trees. More research is needed in water deficit mitigation, establishing nutrient sufficiency and deficiency levels in urban trees the role of fertilization in disease remediation and increased pathogenesis, and the effects of long term fertilization on trees in the urban landscape (Watkins, 1998).

Several studies had been done for increasing the oil productivity and quality of oil in oil crops (Kalannavar, 2008; Yin *et al*., 2010; Suriharn *et al.,* 2011). Thus, this study was conducted to evaluate the growth response of jatropha shrubs to combined fertilizer and irrigation by mixed industrial drainage water.

Materials and Methods

A pot experiments was conducted in greenhouse of the National Research Centre, Dokki, Giza, Egypt during 2011 summer season to evaluate the effect of combined fertilizer (NPK fertilizers) and irrigation by mixture of industrial drainage water (IDW) on mineral status of jatropha plants. The treatments were as follow:-

a) Irrigation by IDW:

1. S_0= 0 IDW + 100% fresh water
2. S_1 = 25% IDW + 75% fresh water
3. S_2 = 50% IDW + 50% fresh water
4. S_3 = 75% IDW + 25% fresh water

b) Combined fertilizer:

1. $N_0P_0K_0$= Without mineral fertilizers
2. $N_3P_3K_3$= 3g N+3g P+3g K / pot (100ppm of N, P and K)
3. $N_6P_6K_6$ = 6N+6g P+6g K / pot (200ppm of N, P and K)

Metallic pots were used; every one contained 30 Kg of air dried clay soil taken from Kerdasa region, Giza Governorate. The inner surface of the pots was coated with three layers of bitumen to prevent direct contact between the soil and metal. Jatropha seeds (*Jatropha curcas* L.) were sown at May, 1, 2011 in the summer season. Plants were thinned twice, the 1st 21 days after sowing and the 2nd two weeks later. Ammonium sulfate (20.5% N), Calcium super phosphate (15.5% P_2O_5) and potassium sulfate (48.5% K_2O) were used in preparing the combined fertilizer. Irrigation with mixed drainage water in different concentrations was started 21days days after sowing. Some physical and chemical properties of the used soil are determined as described by Klute (1986) and Page *et al.* (1982) and provided in Table (1).

Leaves dry weight (g/plant), N, P, K, Ca and Na concentrations (%) and content (mg/plant) were recorded and Na, K and Ca ratios (K:Na, Ca:Na and Ca:(Na+K)) were calculated. Leaves samples were collected, cleaned, dried in an electric oven at 70 ºC and ground in a stainless steel mill. Portions of dried plant materials were ground and wet-digested and analyzed for nitrogen, phosphorus, potassium, sodium and calcium were done using the methods described by Cottenee *et al*. (1982).

Experimental treatments were replicated six times. Analysis of variance (ANOVA) was used to separate means and significant differences at $P < 0.05$ were determined by the least significant difference (LSD) test Snedecor and Cochran (1989).

Table (1): Physical and chemical properties of used soil.

A: Soil physical analysis				
Sand				
Course	Fine	Silt	Clay	Soil texture
7.20	14.25	30.22	48.33	Clay

B: Soil chemical analysis													
pH 1:2.5	EC dSm^{-1} 1:5	$CaCO_3$ %	CEC C mole Kg^{-1}	OM %	Soluble cations and anions me/100 g soil								
					Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{-2}
7.15	1.3	2.53	33.5	1.3	1.82	0.23	2.38	1.27	0.0	0.91	1.9	1.89

Available macro-nutrients %			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

Table (2): Industrial drainage water analysis.

pH	EC dSm^{-1}	Cations and anions me./L							
		Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
7.19	1.12	6.5	2.0	2.5	2.5	--	5.9	5.0	0.8

Results and Discussion

Leaves dry weight (g/plant): Leaves dry weight responded negatively with increasing IDW percentage and positively to the application of combined fertilizer (Figure 1). Hashemi *et al.* (2010) reported that salinity decreased plant growth parameters such as tissue fresh and dry weights. These decreases were accompanied by increased lignin contents, Na^+ ion accumulation, increased lipid peroxidation and decreased chlorophyll contents in plants. The physicochemical analysis of the waste waters revealed that the amount of Na^+, K^+, Ca^{+2} Zn^{+2}, Cu^{+2}, Fe^{+2}, Cl^-, SO_4^{-2} and the degree of electrical conductivity were often above the limits of the standard for irrigation water, and some of these properties would be severely detrimental to crop growth (Gadallah, 1996). In contrast, Wu *et al.* (1996) mentioned that wastewater irrigation did not affect the growth rates of the turf grass.

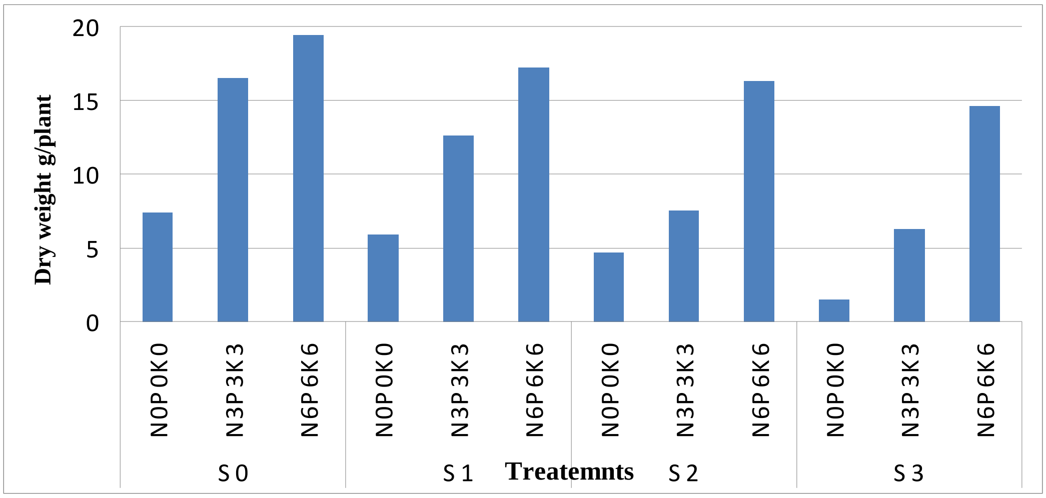

Figure (1): Effect of NPK fertilization and irrigation by mixed industrial drainage water on leaves dry weight of jatropha.

$N_0P_0K_0$= without mineral fertilizer, $N_3P_3K_3$= 3g N+3g P+3g K/ pot and $N_6P_6K_6$ = 6N+6g P+6g K / pot, S_0 S_1 S_2 and S_3 are 0, 25, 50 and 75% IDW, respectively.

The improving effect of NPK fertilizer on dry weight may be related to 1) enhancing of mineral absorption and distribution in different organs in plants as well as the effect of these elements in different metabolic processes in plant tissues and also on the environment, microbial activity and soil properties (Li *et al.,* 2010; Agbede, 2010; Zhai *et al.,* 2011), 2) increasing rate of new cell formation (Mohapatra and Panda, 2011).

The highest value was that of the control (S_0) with addition of $N_6P_6K_6$ fertilizer, while, the irrigation with S_3 mixture without fertilizer addition gave the lowest dry weight. It can be observed that, addition of mineral fertilizer led to decrease the differences between treatments especially with irrigation by S_3 mixture (high IDW percentage) and convert the severity of decline caused by salinity stress to become smoother. This may be refer to, mineral fertilization promotes the growth and the plant become more healthy, consequently, increase plant ability to alleviate the effects of abiotic stresses including salt stress, metal toxicity and nutrient imbalance. With adequate nutrient supply, plants that are limited in growth due to salinity stress would have a higher content of mineral nutrients than plants under comparable fertility but not limited in growth by salinity stress, these results are in line with those reported by (Hussaini *et al.,* 2008) under moisture stress.

Macronutrients concentrations (%): Data presented in Figure (2) indicated that 75% mixed drainage water lowered the concentration of macronutrients more than the other mixed water. The highest depression was shown in N and P concentrations. Sodium concentration has shown to be less affected by the mixtures of IDW. This could be attributed to the ability of jatropha plants to control Na level in leaves. Potassium and calcium show a slight increase by S_1 treatment and tend to decrease with increasing IDW percentage in irrigation water. This depression in nutrient concentrations, caused by direct competition between ions or by increased osmotic potential of the solution reducing the mass flow of mineral nutrients to the root surface (Zhu, 2001). In this respect, Khorami *et al.* (2011) showed, with increasing salt stress, Na^+ concentration increased but K and Ca concentration. Kchaou *et al.* (2010) revealed that salinity increased Na and Cl concentration and accumulation in olive leaves and roots of 5 varieties of one year old olive trees. Maurer *et al*. (1995) showed, in trees irrigated by different treated waste water, leaf nutrient levels were generally within acceptable ranges for N, P, K, Ca, Mg, and Na.

As for fertilization effect, there are a continuous increases in N and K concentrations, with increasing fertilization rate, however P, Ca and K gave the approximately the same values with both fertilization rates. In contrast, Na concentration decreased with addition of $N_6P_6K_6$ than other treatments especially under S_0, S_2 and S_3 mixtures, this may be due to increasing K absorption led to decrease Na absorption. Tahir *et al.* (2006) reported that potassium has a significant role in improving plant water status and mitigating the toxic effects of Na. Hussaini *et al.* (2008) found that varying levels of nitrogen and phosphorus influenced the concentration of nutrients in the maize grain and stover significantly. Several workers found that fertilization with nitrogen, increased the concentrations of nitrogen and phosphorus, in the plant tissue (Gastal and lemire, 2002; Lin *et al.,* 2009 and Rahman *et al.,* 2011), as well as increasing potassium or phosphorus concentrations (Besharati and Rastin, 1999). These increments could be due to 1) Nitrogen is a major nutritional element required for tissue differentiation and it's a component of many important structural, genetic and metabolic compounds in plant cells. It is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e. photosynthesis). It is also a major component of amino acids, the building blocks of proteins. Some proteins act as structural units in plant cells while others act as enzymes, making possible many of the biochemical reactions on which life is based. 2) Phosphorus is a component of energy-transfer compounds, such as ATP (adenosine triphosphate) which allows cells to conserve and use the energy released in metabolism. Finally, P is a significant component of nucleic acids such as DNA, the genetic material that allows cells (and eventually whole plants) to grow and reproduce (Marschner, 1995; Carelli *et al.*, 2006; Tcherkez and Hodges, 2008). 3) Potassium is an essential element for plant growth and reproduction as it activates several enzymes especially in the metabolization of carbohydrates, Protein synthesis is especially dependent on potassium at several stages of amino acids activation, It plays a potential role in the transport of water and essential nutrient throughout the plant in the xylem and Plants also depend upon potassium to regulate the opening and closing of stomata (the pores through which leaves exchange carbon dioxide, water, vapor oxygen with the atmosphere (Marschner, 1995; Armengaud *et al.,* 2004 and Ashley *et al.,* 2005).

Examination of date in Figure (2) indicated that the highest improving in the concentration of N and K by $N_6P_6K_6$ was shown under irrigation by fresh water; however for P by $N_3P_3K_3$ under fresh water. Furthermore, for Na and Ca concentrations response, the highest values were obtained by N0P0K0 under irrigation with 25% IDW. Nevertheless, Na concentration, generally, decreased with addition of $N_6P_6K_6$ fertilizer rate in comparable with unfertilized treatment**.** The fluctuation in nutrients response to studied factors may be attributed to nutrient concentrations affected by 1) the volume of plant growth, where, increasing plant growth led to decrease nutrients concentrations by dilution effect 2) increasing harmful stresses of IDW could affect root health accordingly decreased nutrient uptake, although, increasing nutrient concentrations in rhizosphere.

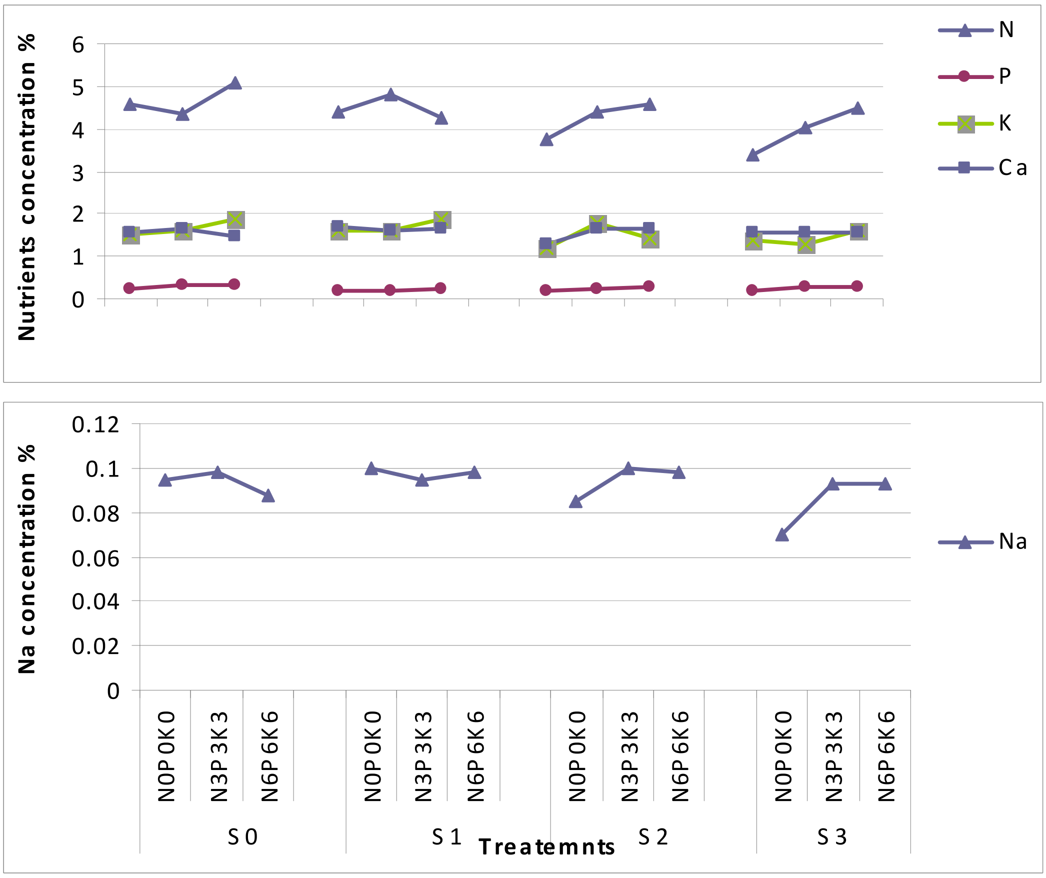

Figure (2): Effect of NPK fertilization and irrigation by mixed industrial drainage water on macronutrient concentrations.

$N_0P_0K_0$= without mineral fertilizer, $N_3P_3K_3$= 3g N+3g P+3g K/ pot and $N_6P_6K_6$ = 6N+6g P+6g K / pot S_0 S_1 S_2 and S_3 are 0, 25, 50 and 75% IDW, respectively.

Macronutrients content: Data of nutrients content were presented in Table (3). These data showed a negative relationship was observed between the increase of drainage water percentage in irrigation water and nutrients content in jatropha plants, where, the content of all determined nutrients decreased profoundly with the increase in drainage water mixed with the fresh irrigation water. Therefore, Ca accumulation decreased by 12.6, 32.2 and 47.5 with irrigation by S_1, S_2 and S_3 treatments compared to control (S_0). It seems that high Na^+ concentration inhibits uptake of Ca^{2+}. The Ca^{2+} plays an important role in regulating ion transfer into plant cells growing in saline medium. Also, calcium can affect membrane stability and ion translocations (Khorami *et al.*, 2011). In addition, calcium is a non-toxic inorganic nutrient that is very effective in detoxifying high concentrations of other elements in plants under saline medium (Greenway and Munns, 1980).The highest percentage of increment was shown in N and K content. On the other side, the lowest percentage was shown in Na as well as P uptake (Table 3). Irrespective of irrigation effect, all nutrients content increased significantly by addition of combined fertilizer in its both rates compared to control ($N_0P_0K_0$). The second fertilization rate ($N_6P_6K_6$) was more superior than the first one ($N_3P_3K_3$). These results are consistent with the findings of Li *et al.* (2010) reported that the NPK combination was found to improve the nutrients uptake, and the total N uptakes during the above periods were 10.0, 14.8 and 10.6 times higher than that of PK treatment, respectively, and 3.7, 1.8 and 5.1 times higher than those of NK treatment, respectively, but, were similar to NP treatment. The total P uptakes were 4.6, 6.8 and 5.3 times higher than those of PK treatment, and were 2.4, 2.3 and 2.9 times higher than those of NK treatment, respectively, but were similar to NP treatment. The uptake of nutrients and their distribution to different parts of the maize plants have been found too vary primarily with the fertility of the native soil application of chemical fertilizers, the growth stage of the, plant and the environmental conditions (Marschner 1995). In contrast, Wu *et al.* (1996) reported that no significant increase of Ca^{2+}, K^{+}, and Mg^{2+} uptake was detected under the wastewater irrigation treatment. However, the Cl uptake was significantly different between irrigation treatments. It was found that in the spring, in the turf plots irrigated by 1/20 concentration wastewater, an amount equivalent to 60% of the applied Cl was taken up and removed in the Kentucky blue grass and ray grass.

Data noted in Table (3) showed that generally, NPK fertilization enhancing minerals content in jatropha leaves. Under irrigation with water contains 25% IDW, K content increased with increasing fertilization rate, while Ca slightly affected but P and Na seemed to be without effect. Moreover, when the percentage of IDW increased to be 50 and 75% the uptake of K, Na and Ca sharply increased with increasing fertilization rate compared to control ($N_0P_0K_0$).

Table (3): Effect of NPK fertilization and irrigation by mixed industrial drainage water on the mineral content of jatropha leaves

Industrial drainage water %	Combined fertilizer g/pot	Macronutrients mg/plant				
		N	P	K	Na	Ca
S_0	$N_0P_0K_0$	337.4	17.8	111.7	7.0	116.2
	$N_3P_3K_3$	717.8	54.5	265.7	16.2	269.0
	$N_6P_6K_6$	985.5	58.2	364.7	17.1	285.2
S_1	$N_0P_0K_0$	259.0	11.8	95.6	5.9	99.7
	$N_3P_3K_3$	604.8	23.9	202.9	12.0	200.3
	$N_6P_6K_6$	734.4	43.0	323.4	16.9	285.5
S_2	$N_0P_0K_0$	176.7	9.4	55.0	4.0	59.2
	$N_3P_3K_3$	329.3	18.8	135.0	7.5	124.5
	$N_6P_6K_6$	744.9	44.0	228.2	16.0	270.6
S_3	$N_0P_0K_0$	51.2	3.0	20.9	1.1	23.7
	$N_3P_3K_3$	253.9	16.4	81.3	5.9	97.7
	$N_6P_6K_6$	658.5	38.0	235.1	13.6	230.7
Mean values of irrigation treatments	S_0	680.2	43.5	247.4	13.4	223.4
	S_1	532.8	26.2	207.3	11.6	195.2
	S_2	417.0	24.1	139.4	9.2	151.4
	S_3	321.2	19.1	112.4	6.8	117.3
Mean values of NPK	$N_0P_0K_0$	206.1	10.5	70.8	4.5	74.7
	$N_3P_3K_3$	476.4	28.4	171.2	10.4	172.9
	$N_6P_6K_6$	780.8	45.8	287.8	15.9	268.0
LSDat5%	Ir	261.0	6.54	N.S	7.91	87.2
	Fer	204.0	10.0	56.1	3.27	30.2
	IrXFer	N.S	17.4	112.2	7.38	60.4

$N_0P_0K_0$= without mineral fertilizer, $N_3P_3K_3$= 3g N+3g P+3g K/ pot and $N_6P_6K_6$ = 6N+6g P+6g K / pot. S_0 S_1 S_2 and S_3 are 0, 25, 50 and 75% IDW, respectively.

Sodium, potassium and calcium ratios: The concentrations of K Na and Ca in plants and their ratios are widely used as screening parameters in ranking varieties for their tolerance to salt toxicity

(Eker *et al.*, 2006). No considerable differences were obtained in K:Na and Ca:Na ratios with increasing IDW in irrigation water. Although, reduction in K:Na ratio under S_2 treatment was observed, In addition to, Ca:(K+Na) ratio was increased gradually with increasing IDW percentage (Figure 3).

Combined fertilizer application improved the K:Na in parallel to the increase of fertilizer rate but depressed Ca:Na and Ca:(Na+K) ratios (Figure 3). These results confirm that addition of the combined fertilizer to jatropha plant led to maintaining a better nutrition with K^+ and Ca^{++}, limiting Na^+ concentration and consequently higher K:Na ratio, subsequently, increase jatropha abiotic stress tolerance, this may be refer to a direct effect of applied K, displacing Na, and causing loss of Na from the root tissue. Jampeetong and Brix (2009) indicated that Na^+ competes with K^+ for uptake into cells. S_2 treatment was reveres the effect of combined fertilizer, where K:Na ratio increased as the rate of fertilizer increased except under 50% mixed IDW treatment. On reverse, Ca:(K+Na) was decreased with increasing fertilization rate under S_0, S_1 and S_3, except under 50% mixing of IDW (S_2) which increased by $N_6P_6K_6$ treatment (Figure 3).

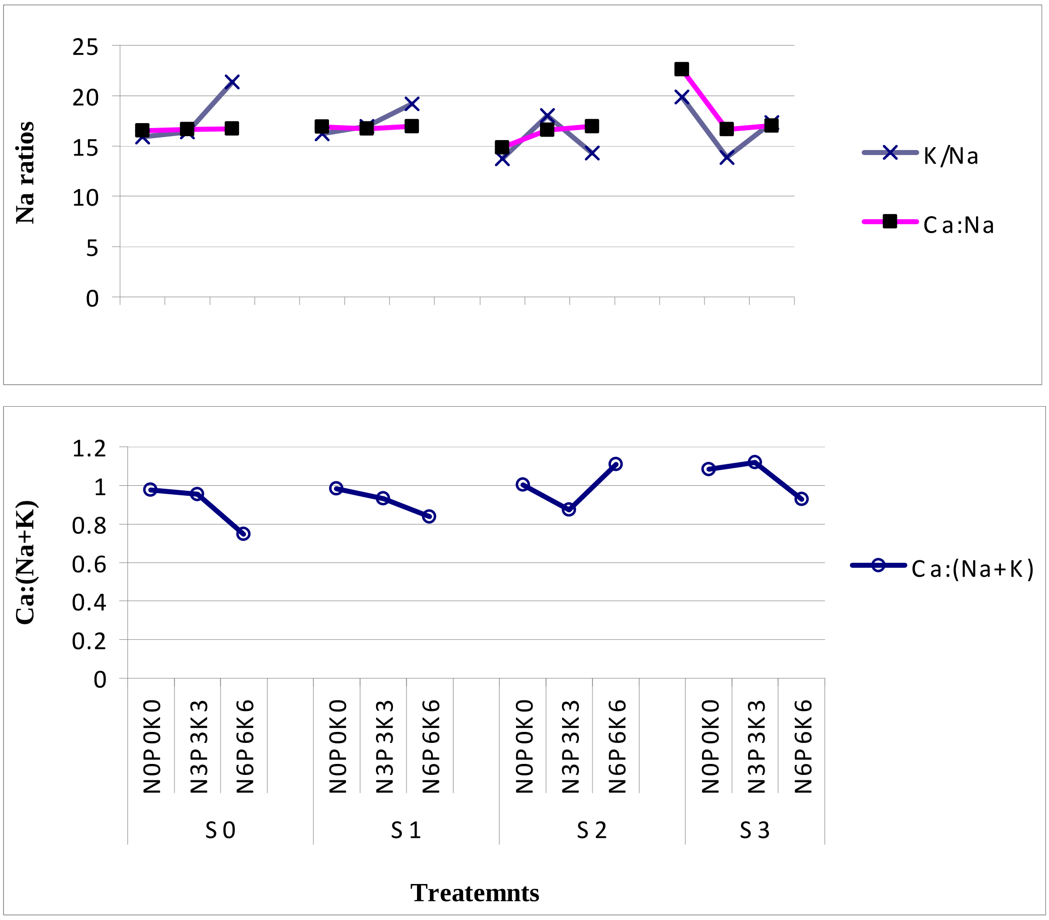

Figure (3): Effect of NPK fertilization and irrigation by mixed industrial drainage water on sodium, potassium and calcium concentrations of jatropha leaves.

$N_0P_0K_0$= without mineral fertilizer, $N_3P_3K_3$= 3g N+3g P+3g K/ pot and $N_6P_6K_6$ = 6N+6g P+6g K / pot. S_0 S_1 S_2 and S_3 are 0, 25, 50 and 75% IDW, respectively.

Values of K:Na, Ca:Na and Ca:(Na+K) ratios ranged between (13.8-21.4), (14.8-22.6) and (0.75-1.12), respectively.

It can be concluded that, the balanced fertilization is essential for enhancing growth, nutrient status and mineral ratios in jatropha plants and results reveal application of $N_6P_6K_6$ to be beneficial for improved plant ability to survival with abiotic stress like irrigation with low quality water. While, the fertilizer requirements studies are need further long-term experiments using more different combinations of N, P and K fertilizers.

References

Agbede, T.M. 2010. Tillage and fertilizer effects on some soil properties, leaf nutrient concentrations, growth and sweet potato yield on an Alfisol in southwestern Nigeria Original Research Article. Soil Tillage Res., 110(1): 25-32.

Armengaud, P.; Breitling, R. and Amtmann, A. 2004. The potassium-dependent transcriptome of Arabidopsis reveals a prominent role of jasmonic acid in nutrient signalling. Plant Physiol., 136: 2556–2576.

Ashley, M.K.; Grant, M. and Grabov, A. 2005. Plant responses to potassium deficiencies: a role for potassium transport proteins. J. Exper. Botany, 57(2): 425-436.

Bedbabis, S.; Rouina, B.B. and Boukhris, M. 2010. The effect of waste water irrigation on the extra virgin olive oil quality from the Tunisian cultivar Chemlali. Original Research Article. Sci. Horti., 125(4): 556-561.

Besharati, H. and Rastin, N.S. 1999. Effect of application *Thiobacillus* spp. Inoculants and elemental sulfur on phosphorus availability. Iran J. Soil Water Sci., 13: 23-39.

Carelli, M.L.; Fahl, J.I. and Ramalho, J.D. 2006. Aspects of nitrogen metabolism in coffee plants . Braz. J. Plant Physiol. 18(1): 1-17.

Cottenie, A., M. Verloo, L. Kiekense, G. Velghe and Camerlynck, R. 1982. Chemical Analysis of Plants and Soils. State Univ. of Gent, Belgium, Hand Book, 1-63.

Da Schio, A. 2010. *Jatropha curcas* L., a potential bioenergy crop. On field research in Belize. M.Sc. dissertation. Padua University, Italy and Wageningen University and Research centre, Plant Research International, the Netherlands.

Eker, S.; Comertpay, G.; Konuskan, O.; Ulger, A.C., Oztrk, L. and Cakmak, I. 2006. Effect of salinity stress on dry matter production and ion accumulation in hybrid maize varieties. Turkish J. Agric. Fores., 30: 365-373.

Farook, H.; Siddqu, M.T.; Farook, M.; Qadir, E. and Hussien, Z. 2006. Growth, Nutrient Homeostatis and Heavy Metal Accumulation In Azadirachta indica and Dalbrgia sissoo Seedlings Raised from Waste Water. Inter. J. Agric. Bio., 8(4): 504-507.

Gadallah, M.A. 1996. Phytotoxic effects of industrial and sewage waste waters on growth, chlorophyll content, transpiration rate and relative water content of potted sunflower plants. Water Air Soil Pollu., 89 (1-2): 233-247.

Gastal, F. and Lemaire, G. 2002. N uptake and distribution in crops: an agronomical and ecophysiological perspective. Journal of Experimental Botany, Inorganic Nitrogen Assimilation, Special Issue, 53 (370):789 - 799.

Glenn, E.P.; Mckeon, C.; Gerhart, V.; Nagler, P.L.; Jordan, F. and Artiola, J. 2009. Deficit irrigation of a landscape halophyte for reuse of saline waste water in a desert city. Landscape and Urban Planning, 89(3-4): 57-64

Greenwey, H. and Munns, R. 1980. Mechanism of salt tolerance in nonhalophyte. Ann. Rev. Plant Physiol., 31: 149-190.

Harris, R.W. 1992. Arboriculture: Integrated management of landscape trees shrubs, and vines. 2nd Ed. Englewood Cliffs, New Jersey: Prentice Hall.

Hashemi, A.; Abdolzadeh, A. and Sadeghipour, H.R. 2010. Beneficial effects of silicon nutrition in alleviating salinity stress in hydroponically grown canola (*Brassica napus* L.), plants. Soil Sci. Plant Nutr., 56(2): 244-253.

Hussaini, M.A.; Ogunlela, V.B.; Ramalan A.A and Falak, A.M. 2008. Mineral Composition of Dry Season Maize (*Zea mays* L.) in Response to Varying Levels of Nitrogen, Phosphorus and Irrigation at Kadawa, Nigeria. World J. Agric. Scie., 4 (6): 775-780.

Jamil, S.; Abhilash, P.C.; Singh, N. and Sharma, P.N. 2009. *Jatropha curcas*: a potential crop for phytoremediation of coal fly ash. J. Hazard Mater., 15:172(1): 269-75.

Jampeetong, A. and Brix, H. 2009. Effects of NaCl salinity on growth, morphology, photosynthesis and praline accumulation of Salvinia natans. Aquatic Botany, 91: 181-186.

Kalannavar, V. 2008. Response of *Jatropha curcas* to nitrogen, phosphorus and potassium levels in northern transition zone of Karataka. M.Sc. Thesis, University of Agricultural Sciences, Dharwad

Kanal, A. and Kuldkepp, P. 1993. Direct and residual effect of different organic fertilizers on potato and cereals. J. Agron. Crop Sci., 171: 185-193.

Kchaou, H.; Larbi, A.; Gargouri, K.; Chaieb, M.; Morales, F. and Msallem, M. 2010. Assessment of tolerance to NaCL salinity of five olive cultivars, based on growth characteristics and Na and Cl exclusion mechanism. Scientia Horticulturtae, 124: 308-315.

Khorami, R., Safarnejad, A. and Shourvarzi, M. 2011. Effect of salt stress on ion distribution and proline accumulation in *Foeniculum vulgare* using in vitro technique. International Journal of Science and Nature, 2(2): 168- 175.

Klute, A. 1986. Methods of Soil Analysis: Part I: Physical and mineralogical Methods. 2^{nd} ed., Amer. Soc. Agron. Monograph No. 9, Madison, Wisconsin. U.S.A.

Li, W.; Lu, J.; Chen, F. and Li, X. 2010. Effect of NPK application on yield, nutrients and water utilization under sudangrass and ryegrass rotation regime. Agric. Sci. China, 9 (7): 1026-1034.

Lin, X.Q.; Zhu, D.F.; Chen, H.Z.; Cheng, S. H. and Uphoff, N. 2009. Effect of plant density and nitrogen fertilizer rates on grain yield and nitrogen uptake of hybrid rice (*Oryza sativa* L.). J. Agricultural Biotechnol. Sustain. Develop., 1: 44-53.

Marschner, H. 1995. Part I. Nutritional physiology, in: Mineral Nutrition of Higher Plants. 2^{nd} (Eds.), Marschner, H., Academic Press, London. pp. 18-30, 200-255, 313-363. www.amjbot.org/cgi/content/full/92/8/1421

Maurer, M.A.; Davies, F.S. and Graetz, D.A. 1995. Reclaimed Waste water irrigation and fertilization of mature 'Redblush' grapefruit trees on Spodosols in Florida. Amer. Soc. Hort. Sci., 120(3): 394-402.

Mohapatra, S. and Panda, P.K. 2011. Effects of Fertilizer Application on Growth and Yield of Jatropha curcas L. in an Aeric Tropaquept of Eastern India. Notulae Scientia Biologicae, 3(1): 95-100.

Mottagem, M.; Hian, A.; Pidashti, H.; Bahmanyar, M.A. and Abbasian, A. 2008. Leaf and seed micronutrients accumulation in soybean cultivars in response to integrated organic and chemical fertilizer application Pakistan J. Biol. Sci., 11: 1227–1233.

Page, A.L.; Miller, R.H. and Keeny, D.R. 1982. Methods of Soil Analysis, Part II Chemical and Microbiological Properties. 2^{nd} ed., Amer. Soc. Agron. Monograph No. 9, Madison, Wisconsin. U.S.A.

Rahman, M.M.; Soaud, A.A.; Golam, A.F. and M. Sofian-Azirun, M. 2011. Growth and nutrient uptake of maize plants as affected by elemental sulfur and nitrogen fertilizer in sandy calcareous soil. African Journal of Biotechnol., 10(60): 12882-12889.

Snedecor, G.W. and. Cochran, W.G 1989. Statistical Analysis 8^{th} ed., Iowa State Univ., Iowa, USA.

Suriharn ,B.; Sanitchon, J.; Songsri, P. and Kesmala, T. 2011. Effects of pruning Levels and fertilizer rates on yield of physic nut (*Jatropha curcas* L.). Asian J. Plant Sci., 10: 52-59.

Tahir, MA; Rahmatullah; Aziz, T.; Ashraf, M.; Kanwal, S. and Maqsood, M.A. 2006. Beneficial Effects of Silicon in Wheat (*Triticum Aestivum* L.) Under Salinity Stress. Pakistan J. Botany, 38(5): 1715-1722.

Tcherkez, T. and Hodges, M. 2008. How stable isotopes may help to elucidate primary nitrogen metabolism and its interaction with (photo) respiration in C3 leaves. J. Exp. Bot., 59: 1685-1693.

Trabucco, A.; Wouter, M. J.; Achten, A.; Bowe, C.; Aerts, R.; Orshoven, J.V.; Norgrove, L. and Muys, B. 2010. Global mapping of *Jatropha curcas* yield based on response of fitness to present and future climate. GCB Bioenergy, 2(3): 139-151.

Watkins, J.R. 1998. Fertilization and woody plant nutrition in the context of the urban forest. M. Sc. Thesis, Faculty of the Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

World Agroforestry Centre 2007. When oil grows on trees. World Agroforestry Centre press release.

Wu, L.; Chen, J.; Mantgem, P.V. and Harivandi, M.A. 1996. Regenerate wastewater irrigation and ion uptake in five turf grass species. J. Plant Nutr.,19(12):1-15.

Yin, L., Hu, T.X.; Lui, Y.A.;. Yao, S.F; Ma, J. Liu W.T. and He C. 2010. Effect of drought on photosynthetic characteristics and growth of *Jatropha curcas* seedlings under different nitrogen levels. Ying Yong Sheng Tai Xue Bao, 21: 569-576.

Zhai, L.; Liu, H.; Zhang, J.; Huang, I.N.G. and Wang, B. 2011. Long-term application of organic manure and mineral fertilizer on N_2O and CO_2 emissions in a red soil from cultivated maize-wheat rotation in China. Agric. Sci. China, 10 (11): 1748-1757.

Zhu, J.K. 2001. Plant salt tolerance trends. Plant Sci., 6: 66-72.