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The Growth and Production of Jojoba Plant under NPK-Fertilization and Irrigation with Industrial Wastewater

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THIS RESEARCH aims to study the growth and production of jojoba plant as abiofuel crop under fertilization with N, P and K and irrigation with industrial wastewater as a source of untraditional irrigation water. So, over two consecutive growing seasons on 6th year fruiting Jojoba shrubs grown on sandy soil at private orchards located in El-Assiuty Valley, Assiut Governorate, Egypt, a field experiment was laid out in a randomized complete block design with split plot technique where the main factor was the different nitrogen sources (i.e. urea "U", ammonium sulphate "AS", ammonium nitrate "AN"and calcium nitrate "CA") at 240 kgNha^{-1}, while the sub main factor was allocated for five combinations of P and K fertilizer as follows [control; no application, P1; 75P_2O_5 ha^{-1}, K1; 60 kgK_2Oha^{-1}, P1K1; 75P_2O_5 + 60 kgK_2Oha^{-1} and P2K2; 150P_2O_5 + 120 kgK_2Oha^{-1}]. Results indicated that using 240 kgNha^{-1} as ammonium sulphate with 150P_2O_5 + 120 kgK_2Oha^{-1} showed the highest significant increasing in most of the studied parameters such as nutrients availability, vegetative growth and yield of jojoba plants. Bioconcentration factor (BCF) for heavy metals in leaves and seeds of jojoba shrub showed a trend in the following order; Cu > pb > Mn > Zn > Fe. More future researches are still required to study the side effects of using artificial wastewater on oil quality of jojoba seeds.

Keywords: Nitrogen forms, Macro-elements application**,** Bioconcentration factors, Heavy metals

Introduction

Water, food security and energy are among the most important challenges which faces Egypt, especially in recent time with the continuing in building and filling the Renaissance Dam in Ethiopia, which may affect the annul share of Egypt from Nile water. The annual per capita share of water had dropped under the global water scarcity mark of 1000 m^3. The country has reached a stage of water poverty (less than 700 m^3) with an average of 663m^3 per capita and is expected to fall below 582 m^3 by 2030. So, recently, the ability to define and implement a proper sustainable water resource plan is the main challenge that faces Egypt in the near future to meet the basic needs of the growing population (World Water Development Report, 2014 and Nasr et al., 2019).

Jojoba (*Simmondsia chinensis*, L. Schneider) is one of the newly introduced promising biofuel crops. It is native to the Sonora desert of northern Mexico and south western USA. Jojoba plants grow well in arid and semi-arid regions where it can tolerate drought and salinity conditions. The high economic value of jojoba shrub is due to its seeds contain about 50% oil by weight (Bashir et al. 2007). These oils and its derivatives seem to have potential uses in diverse products as cosmetics, pharmaceuticals, lubricants, biofuels, electrical insulators, foam-control agents, high pressure lubricants, heating oils, plasticizers, fire retardants, and transformer oils. Moreover, Jojoba oil is a source of long-chain alcohols and acids with double bonds in slightly different positions than those in other natural fatty acids. The almost complete absence of glycerin indicates that it differs radically from all other known seed oils; it is not a fat but a liquid wax (Francis et al., 2005; Jongschaap et al., 2007 and Nasr et al. 2019)

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Relatively little is known regarding fertilization requirements of Jojoba. In a previous study Yermanos (1982) designated that applications of 50 kg N or 50 kg of P as P_20_5/ha alone or combined together for three consecutive crops had no significant effect on vegetative growth or seed yield in Jojoba. Similarly, Osman et al. (2012) pointed out that the NPK fertilization had principally no significant effects on vegetative growth of Jojoba grown in Western Saudi Arabia. On the contrary to these studies, application of comparatively high doses of NPK fertilizers in irrigated fields of Jojoba were reported to stimulate positive vegetative growth (Benzioni and Nerd, 1985; Benzioni and Dunstone, 1986), cause early flowering and increase the percentage of floral buds that broke dormancy (Nerd and Benzioni, 1988). Lovenstein (1985) expected that about 58, 11, 22, 4 and 4kg/ha of N, P, K, S and Mg are needed for the production of 3MT of seeds per ha from Jojoba cultivations. Adams et al. (1977) and Reyes et al. (1977) pointed out that response of Jojoba to fertilizer additions depends on the root type (tap vs. fibrous), soil temperature and season of growth.

For using jojoba wax as a biofuel this require cultivated jojoba shrubs in a large scale and this is can be executed in Egypt where about 95% of Egypt soils are desert which are suitable for cultivating jojoba plant. In addition, using untraditional water such as industrial wastewater, agricultural drainage water and sewage drainage water for irrigation is possible but it has high content of salinity especially in agricultural drainage water and heavy metals either in industrial or in agricultural drainage water. Consequently, irrigation with this untraditional water leads to accumulate heavy metals in plant tissues in a high quantity resulting disturbance in the different plant physiological functions which reflect on growth and yield of jojoba shrubs irrigated with this type of water (El-Sayed, 1998 and Hedia, 2014).

Consequently, this study aims to determine the optimum source of nitrogen with the optimum combination of both phosphorus and potassium to obtain the optimum growth and yield of jojoba plant under irrigation with industrial drainage water. Also, to assess heavy metal accumulation as the Biological Concentration Factor (BCF) under the arid environments of Egypt.

Materialsand Methods

A field experiment was carried out on 6-year-old jojoba fruiting shrubs plants grown on sandy soil under drip irrigation with industrial wastewater in a private farm to study the growth and production of jojoba plant as a biofuel crop under fertilization with N, P & K and irrigation with industrial wastewater as a source of untraditional irrigation water during two successive growing seasons (2017/2018 and 2018/2019). Some chemical and physical analyses of the farm soil are given in (Table 1) and some chemical analysis of irrigation water are given in (Table 2) according to procedures.

TABLE 1. Some physical and chemical analyses of experimental soil

Soil depth (cm)	Sand %	Silt %	Clay%	Texture	pH	EC dSm^{-1}	OM gkg^{-1}	$CaCO_3$ gkg^{-1}
0-30	92.50	5.50	2.01	Sandy	7.9	1.54	9. 4	16.41
30-60	92.27	5.84	1.90	Sandy	7.2	1.32	8. 7	15.92
	Available nutrients ($mgkg^{-1}$)			**Total heavy metals ($mgkg^{-1}$)**				
	N	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**	**Pb**
0-30	49.1	4.81	56.12	7.33	0.954	2.21	0.319	0.197
30-60	51.67	4.32	59.45	6.4	0.879	2.11	0.294	0.114

TABLE 2. Some water chemical analyses

	pH	EC (dSm^{-1})	Soluble Cations ($mmol_cL^{-1}$)				Soluble Anions ($mmol_cL^{-1}$)			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	SO_4^{-2}	Cl^{-}
Industrial wastewater	7.20	1.763	4.86	2.18	10.87	0.50	Nil	97.60	20.40	28.28

	Available heavy metals ($mgkg^{-1}$)				
	Fe	**Mn**	**Zn**	**Cu**	**Pb**
Industrial wastewater	0.125	0.422	0.099	0.012	0.092
Standard	0.30	-	5.00	2.00	0.01

FAO (1984) and WHO/FAO (2013).

Jojoba shrubs are cultivated in 4 and 2 m distance between rows and shrubs, respectively, i.e., 1250 shrubs/ha, 250shrub of which are male plants (about 20%) and the others are females. Experiment was laid out in split plot design with three replicates where three female plants per replicate. The main plots were randomly assigned to sources of nitrogen fertilizer ammonium sulfate (20.5 %N) (AS), calcium nitrate (15%N) (CN), urea (46 %N) (U) and ammonium nitrate (33%N) (AN) at the rate of 240 Nha^{-1}. The sub main plots were subjected to five combinations of P and K fertilizer as follows [control; no application, P1; $75P_2O_5ha^{-1}$, K1; 60 kgK_2Oha^{-1}, P1K1; $75P_2O_5$ + 60 kgK_2Oha^{-1} and P_2K_2; $150P_2O_5$ + 120 kgK_2Oha^{-1}].

Saplings of jojoba plants were transplanted on 24 May 2011. Phosphorus fertilizer was applied in the form of super phosphate (15.5% P_2O_5) and potassium as potassium sulphate (48% K_2O). All agronomic practices were followed as recommended for jojoba production. The random selected female plants were tagged in each experimental plot and two twigs, each five internodes long, were taken from each plant.

Leaves were collected from each tagged plant at the end of vegetative growth, to carry out the vegetative parameters and air-dried, oven-dried at 70^0C for 72hr and ground and sieved through 2mm sieve and packed in paper bags for chemical analysis. Also, from the same shrub seeds were collected at harvest.

Growth and Yield parameters

The determined growth and yield parameters were shoot length, shoot diameter, number of nods/shoot, leaf width, leaf length, leaf area, seed oil%, seed protein%, 100-seed weight, seed yield/ha, seed oil yield/ha and seed protein yield/ha.

Soil chemical analysis at the end of the experiment

The following determinations were performed in soils; available nitrogen, phosphorus and potassium were determined according to Page et al. (1982), available heavy metals were determined according to Ure (1995) and detected using the(iCAP 6000 series ICP spectrometer-thermo scientific), (ICP-OES) The biological concentration factor (BCF) BCF to trace element concentration in different plant tissues / trace element concentration in soil according to (Ghosh and Singh, 2005).

The Assessment of heavy metals risk in jojoba plant

Geo-accumulation index (I_{geo})

The geo-accumulation index (I_{geo}) is another approach to estimate the contamination levels of trace metals. This method assesses the degree of metal pollution in terms of seven enrichment classes based on the increasing numerical values of the index and could be calculated as follows (Muller, 1969; Rudnick and Gao, 2004):

$$I_{geo} = Log_2(C_x / 1.5b_x) \qquad (1)$$

where C_x is the content of the element in the enriched samples, and b_x is the background value of the element.

Enrichment factor (EF)

The EF was utilized to assess the level of contamination of trace metals in the soil. In the present study, Fe was used as the conservative tracer to differentiate natural components from the anthropogenic activities which resulted from irrigated with industrial wastewater. The EF was calculated as follows (Chen et al., 2007, and Abrahim and Parker, 2008):

$$EF = \left(\frac{(C_x / C_{Fe})_{Sample}}{(C_x / C_{Fe})_{Reference}} \right) \qquad (2)$$

where $(C_x/C_{Fe})_{sample}$ is the a ratio content of the element and Fe in the studied sample, and $(C_x/C_{Fe})_{Reference}$ is the same ratio in the earth's crust (Rudnick and Gao, 2004; Nadimi-Goki et al., 2014).

Contamination factor (CF)

Contamination factor (CF) is the ratio of metal concentration in soil sample to its concentrations in the background. The CF was calculated using the following equation (Hakanson, 1980):

$$CF = C_x/C_r \qquad (3)$$

where C_x and C_r are the mean concentrations of the metal contaminants in the soil samples and background reference material, respectively (Chen et al., 2015).

Plant chemical analysis

Oil content of seed (%), total nitrogen content in leaves and seeds according to Micro-Kjeldahl method (Jackson, 2005), seed protein content by multiplying total nitrogen content by 6.25, potassium content, phosphorus content and total heavy metals in seeds and leaves as described by A.O.A.C (1990).

Statistical analysis

The experiment was conducted as split plot design having nitrogen sources in main plot and combinations of both phosphorous and potassium in sub plot. Data were subjected to statistical analysis of variance according to Snedecor and Chochron (1992) and L.S.D. value for comparison.

Results and Discussion

In the light of that, the used industrial waste water for irrigation falls below the standard level for its heavy metals (Fe, Zn and Cu) but for Pb is more than standard level (Table 2). The results of the average of both studied seasons were presented and discussed follows:

Vegetative growth parameters of jojoba shrubs

As shown in Table 3 significant differences were observed among all nitrogen sources. i.e. ammonium sulfate (AS), calcium nitrate (CN), urea (U), and ammonium nitrate (AN), regarding their effect on all growth parameters; AS had the highest significant effect followed by AN while the lowest one owned to CN. Accordingly, the highest significant growth values were 37.31 cm, 1.63 cm, 10.10, 29.27 mm, 38.73 mm and 8.31cm^2 at 240 kgNha^{-1} as AS, while the lowest ones were 21.41 cm, 0.92 cm, 5.79, 16.80 mm, 22.22 mm and 4.69 cm^2 at 240 kgNha^{-1} as CN for shoot length, shoot diameter, nodes No., leaf width, leaf length and leaf area, respectively.

With respect to the effect of P and K combinations, data indicated that adding P and K either as sole or dual application had more significant effect than no adding (control), nevertheless, the sole application of P and K was less significant effect than the dual one. In addition, all vegetative growth parameters of jojoba shrubs showed the highest significant values with increasing the level of the dual application of both P and K. Where, the achieved average increase percentage for all the studied growth parameters due to the highest level of the dual application of P and K was about 26% compared to the control.

Concerning the interaction effect between nitrogen sources and combinations of P and K, results pointed out that the application of nitrogen in the form of ammonium sulfate (AS) at 240 kgNha^{-1} combined with both P and K at 150 kgP_2O_5 and 120 kgK_2Oha^{-1} resulted in the highest significant values for all the studied growth parameters of jojoba shrubs as follows; 38.30cm, 1.71cm, 10.50, 30.44 mm, 40.27 mm and 8.71cm^2 for shoot length, shoot diameter, nodes No., leaf width, leaf length and leaf area, respectively. The mentioned above results are partially in harmony with those obtained by Adams et al. (1977), Reyes et al. (1977), Yermanos (1982), Benzioni and Nerd (1985), Lovenstein (1985), Benzioni and Dunstone (1986), Nerd and Benzioni (1988),Osman et al. (2012), Gendy et al., 2013 and El-Dissoky (2019).

TABLE 3. Vegetative of growth parameters of jojoba shrubs.

Factor A	AS	CN	U	AN	AS	CN	U	AN
Factor B	Shoot length (cm)				Shoot diameter (cm)			
Control	33.61e	16.46p	20.09n	25.47i	1.48e	0.72p	0.88n	1.12i
P1	36.64d	17.93o	20.58m	28.12h	1.61d	0.79o	0.90m	1.24h
K1	37.62c	23.03k	22.14l	28.61g	1.65c	1.01k	0.97l	1.26g
P1K1	38.41b	23.03k	23.12k	32.63f	1.69b	1.01k	1.02k	1.43f
P2k2	38.80a	24.01j	25.57i	32.63f	1.71a	1.06j	1.12i	1.43f
LSD0.05	A=0.7233 B=0.8087 A*B=0.1349				A=0.0319B=0.0356 A*B=0.006			
	Nodes No				Leaf width (mm)			
Control	9.09e	4.45p	5.44n	6.89i	26.37e	12.91p	15.76n	19.99i
P1	9.92d	4.85o	5.57m	7.61h	28.75d	14.07o	16.14m	22.06h
K1	10.18c	6.23k	5.99l	7.74g	29.52c	18.06k	17.37l	22.45g
P1K1	10.39b	6.23k	6.26k	8.83f	30.13b	18.06k	18.14k	25.60f
P2k2	10.50a	6.50j	6.92i	8.83f	30.44a	18.83j	20.06i	25.60f
LSD0.05	A=0.1964B=0.2196 A*B=0.0365				A=0.567 B=0.634 A*B=0.1058			
	Leaf length (mm)				Leaf area (cm^2)			
Control	34.88e	17.08p	20.85n	26.44i	7.54e	3.70p	4.51n	5.72i
P1	38.03d	18.61o	21.36m	29.19h	8.23d	4.03o	4.62m	6.31h
K1	39.05c	23.90k	22.98l	29.69g	8.45c	5.17k	4.97l	6.42g
P1K1	39.86b	23.90k	24.00k	33.86f	8.62b	5.17k	5.19k	7.32f
P2k2	40.27a	24.91j	26.54i	33.86f	8.71a	5.39j	5.74i	7.32f
LSD0.05	A= 0.751 B=0.8397 A*B=0.1405				A=0.1623 B=0.1815 A*B=0.0289			

Abbreviation: AS: ammonium sulfate, CN: calcium nitrate, U: urea, AN: ammonium nitrate

** Control: no application, P1:75kgP_2O_5ha^{-1}, P2: 150kgP_2O_5ha^{-1}, K1:60kgK_2Oha^{-1}, K2:120kgK_2Oha^{-1}.

TABLE 4. Yield parameters of jojoba shrubs.

Factor A*	AS	CN	U	AN	AS	CN	U	AN
Factor B**	Seed oil, %				Seed protein%			
Control	46.05f	37.9s	40.9n	43.76j	30.25d	25.25l	26.50k	28.00i
P1	47.35d	38.07r	40.95n	45.36h	31.50b	28.50h	28.50h	29.25f
K1	48.46c	38.58q	41.1m	45.15i	31.50b	27.25j	28.00i	30.25d
P1K1	49.53b	39.09p	41.21l	45.51g	31.50b	29.00g	29.75e	31.00c
P2k2	50.57a	40.02o	41.46k	46.84e	32.75a	31.00c	31.00c	32.75a
LSD0.05	A=0.2871 B=0.321 A*B=0.1318				A=0.2694 B=0.3012 A*B=0.0676			
	100-Seed weight (g)				Seed yield ($Mgha^{-1}$)			
Control	81.51e	57.98l	67.44j	77.74f	3.43e	1.68p	2.05n	2.60i
P1	88.42d	61.81k	68.72i	75.67g	3.74d	1.83o	2.10m	2.87h
K1	89.70c	75.11g	72.81h	88.23d	3.84c	2.35k	2.26l	2.92g
P1K1	100.18a	75.11g	75.37g	98.28b	3.92b	2.35k	2.36k	3.33f
P2k2	100.18a	77.67f	81.77e	99.3a	3.96a	2.45j	2.61i	3.33f
LSD0.05	A=1.4402 B=1.6101 A*B=0.4172				A=0.0487B=0.0544 A*B=0.0238			
	Seed oil yield ($Mgha^{-1}$)				Seed protein yield ($Mgha^{-1}$)			
Control	1.58e	0.64p	0.84n	1.14i	1.038f	0.424p	0.543o	0.728k
P1	1.77d	0.69o	0.86m	1.30h	1.18d	0.522o	0.599n	0.839h
K1	1.86c	0.91l	0.93l	1.32g	1.21c	0.640m	0.633m	0.88g
P1K1	1.94b	0.92l	0.97k	1.52f	1.23b	0.682l	0.702l	1.032f
P2k2	2.00a	0.98k	1.08j	1.56e	1.29a	0.760j	0.809i	1.091
LSD0.05	A=0.0222 B=0.0248 A*B=0.0141				A=0.0151 B=0.0169 A*B=0.0087			

* AS: ammonium sulfate, CN: calcium nitrate, U: urea, AN: ammonium nitrate

** Control: no application, P1:75kg$P_2O_5ha^{-1}$, P2: 150 kg$P_2O_5ha^{-1}$, K1:60 kgK_2Oha^{-1}, K2:120 kgK_2Oha^{-1}.

Yield parameters of jojoba shrubs

As presented in Table 4, significant differences were noticed among all nitrogen sources concerning their effect on all yield parameters. In this respect, ammonium sulfate (AS) had the highest significant effect followed by ammonium nitrate (AN) while the lowest one was due to calcium nitrate (CN).

Accordingly, the highest significant yield parameter values were 48.39%, 31.5%, 92g, 3.778 $Mgha^{-1}$, 1.831$Mgha^{-1}$ and 1.191 $Mgha^{-1}$ at 240 $kgNha^{-1}$ as AS, while the lowest ones were 38.73%, 28.20%, 69.54g, 2.132 $Mgha^{-1}$, 0.828 $Mgha^{-1}$ and 0.605 $Mgha^{-1}$ at 240 $kgNha^{-1}$ as CN for seed oil%, seed protein%, 100-seed weight, seed yield, seed oil yield and seed protein yield, respectively. With regard to the effect of P and K combinations, data indicated that adding P and K either as single or binary addition had more significant effect than no application (control), moreover, the single addition of P and K were less significant effect than the dual one. Furthermore, all yield growth parameters of jojoba shrubs showed the highest significant values with increasing the level of the dual application of both P and K, The achieved average increase percentages for all the studied growth parameters due to the highest level of the dual application of P and K compared to the control were 6.10, 15.93, 26.08, 26.54, 31.16 and 44.80% for seed oil%, seed protein%, 100-seed weight, seed yield, seed oil yield and seed protein yield, respectively.

Concerning the interaction effect between nitrogen forms and combinations of P and K, results confirmed that the application of nitrogen in the form of ammonium sulfate (AS) at 240$kgNha^{-1}$ combined with both P and K at 150kgP_2O_5 and 120kgK_2Oha^{-1} resulted the highest significant values for all the studied yield parameters of jojoba shrubs as follows; 50.57%, 32.57%, 100.18g, 3.960 $Mgha^{-1}$, 2.003 $Mgha^{-1}$ and 1.297 $Mgha^{-1}$ for seed oil %, seed protein %, 100-seed weight, seed yield, seed oil yield and seed protein yield, respectively.

The aforementioned results are in accordance with those obtained by Adams et al. (1977), Reyes et al. (1977), Yermanos (1982), Benzioni and Nerd (1985); Lovenstein (1985), Benzioni and Dunstone (1986), Nerd and Benzioni (1988) and Osman et al. (2012).

NPK content in dry leaves and seeds of Jojoba shrubs

Data presented in Table 5, indicated that nitrogen, phosphorus, potassium content (%) were significantly increased as a result of nitrogen fertilization. The average of both studied seasons shows that NPK content (%) in leaves and seeds in plants was obtained with ammonium sulphate followed by, as ammonium nitrate and calcium nitrate gave the lowest data. combinations of P K fertilizer showed significantly increase content (N, P and K) of jojoba compared with control treatment. The highest value of NPK content (%) in leaves and seeds (2.93, 0.27, 1.92, 1.28, 0.0983 and 1.92) for P2K2, respectively. The trend of the treatments of mixture were P2K2> P1K1> K1> P1, while the control treatment gave the lowest values of N, P and K during the two seasons. It is clearly to notice that the interaction between nitrogen fertilization sources and the combination PK treatments significantly increased nitrogen, phosphorus, potassium content (%). The interaction of Ammonium sulphate with P2+K2 was the superior treatment which recorded significant increases (1.31, 0.086 and 0.97% in seeds). Also, in leaves was (3.03, 0.28 and 2.46%) for N, P and K content, respectively. Habib (2005) on Oreodoxa regia seedlings showed that, all nitrogen sources significantly increased the plant height and the ammonium sulphate resulted in the tallest seedlings and the fresh weight of foliage.

The treatment of ammonium sulphate gave the highest contents of phosphors and potassium. In this respect, Khattab et al. (2019) stated that foliar application of NPK on jojoba shrubs gave the highest values for chlorophyll content (chl. A), carotene, macro and micronutrients content.

Micronutrients content in dry leaves and seeds of jojoba shrub

Data in figures (1-5) showed that the heavy metals Fe, Mn, Cu, Zn, Ni, Cr and Pb in leaves and seeds of jojoba plant were significantly affected by the studied different treatments through two seasons. Fe content in leaves and seeds (Fig.1) was accumulated with AS followed by AN and U while CN gave the lowest data. Combinations of P K fertilizer showed significantly decrease content (Fe) of jojoba as compared with control treatment. The value (1069.0, 1005.4, 944.6 and 877.61 mg/kg Fe) was resulted from the treatment of mixture of K1> P1 > P2K2 > P1K1 in leaves; but the value of Fe, in seeds P1> K1> P1K1> P2K2 respectively, while the control treatment gave the highest accumulate in leaves and seeds.

TABLE 5. NPK contents in leaves and seeds of jojoba shrubs

Factor A*	AS	CN	U	AN	AS	CN	U	AN
FactorB**	Leaves N%				Seeds N%			
Control	2.80e	2.49j	2.26k	2.49j	4.48i	4.04l	4.24k	4.48i
P1	2.94c	2.71g	2.49j	2.71g	5.04b	4.56h	4.56h	4.68f
K1	2.89d	2.67h	2.62i	2.62i	5.04b	4.36j	4.48d	4.84d
P1K1	2.94c	2.71g	2.80f	2.71e	5.04b	4.64g	4.76e	4.96c
P2k2	3.03a	2.80e	2.89d	2.99b	5.24a	4.96c	4.96c	5.24a
LSD0.05	A=0.0294 B=0.0152 A*B=0.0399				A=0.0431 B=0.0482 A*B=0.0113			
	Leaves P%				Seeds P%			
Control	0.18g	0.20f	0.16h	0.13i	0.022p	0.027o	0.048l	0.042n
P1	0.24cd	0.22e	0.22e	0.20f	0.054j	0.062h	0.082f	0.049l
K1	0.22e	0.21ef	0.20f	0.19g	0.053k	0.049l	0.064h	0.043m
P1K1	0.25c	0.24cd	0.23d	0.22e	0.080f	0.092c	0.089d	0.058i
P2k2	0.28a	0.28a	0.25c	0.27b	0.086e	0.137a	0.098b	0.072g
LSD0.05	A=0.00446 B=0.0056 A*B=0.0111				A=0.0029 B=0.00422 A*B=0.0029			
	Leaves K%				Seeds K%			
Control	1.39k	1.10p	1.09p	1.28m	0.41j	0.25m	0.34l	0.38k
P1	1.58g	1.37o	1.34n	1.48h	0.64g	0.59h	0.36kl	0.53i
K1	1.71e	1.20k	1.25l	1.74e	0.65fg	0.67f	0.60h	0.59h
P1K1	2.03c	1.42j	1.60g	1.87d	0.71e	0.76d	0.73e	0.67f
P2k2	2.46a	1.45i	1.66f	2.09b	0.97a	0.84b	0.79c	0.79c
LSD0.05	A=0.0258 B=0.0084 A*B=0.0298				A=0.00714 B=0.0123 A*B=0.0231			

* AS: ammonium sulfate, CN: calcium nitrate, U: urea, AN: ammonium nitrate

** Control: no application, P1:75kg$P_2O_5ha^{-1}$, P2: 150kg$P_2O_5ha^{-1}$, K1:60kgK_2Oha^{-1}, K2:120kgK_2Oha^{-1}.

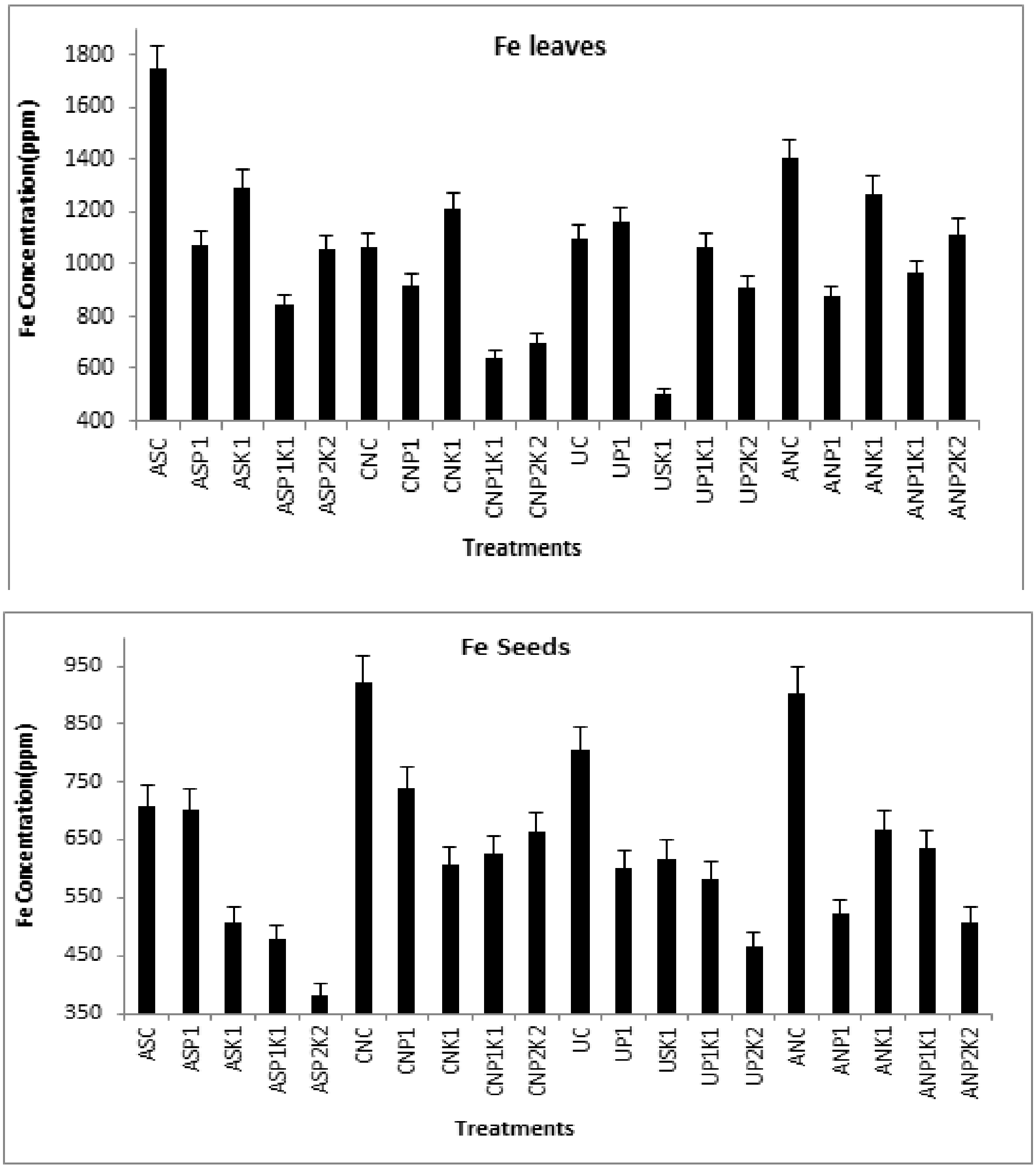


Fig. 1. Fe content in leaves and seeds of jojoba shrub

Notice that Synergism interaction between AS only treatment and plant's uptake of Fe gave the highest accumulative (1746.3 and 922.10 ppm respectively) in leaves and seeds. There is also an antagonistic interaction between Urea K source and Fe gave the lowest accumulative (498.9 ppm) in leaves; but the value of Fe, in seeds estimated at 382.4 ppm by CNP2K2. The results showed also that Fe concentration in jojoba plants accumulated in leaves > seeds.

Cu content in leaves and seeds (Fig. 2) was accumulated with AS followed by, U and AN while CN gave the lowest data. Combinations of P K fertilizer treatments showed significantly decrease content (Cu) by P1 K1 > K1 > P1 > P2K2 in leaves; but, in seeds P1 > K1 > P1K1 > P2K2 respectively, while the control treatment gave the highest accumulation in leaves and seeds. Notice that Synergism interaction between AS only treatment and plant's uptake of Cu gave the highest accumulative (37.53 and 36.37 ppm, respectively in leaves and seeds, There is also an antagonistic interaction between CNK source and Cu, the lowest accumulative (5.72 ppm) was in leaves. while, in seeds estimated at 9.03 ppm by CNP2K2. The results showed also that Cu concentration in jojoba plants accumulated in seeds > leaves.

Mn content in leaves and seeds (Fig.3) was accumulated with CN followed by, AN and U and AS gave the lowest data. Combinations of P K fertilizer treatments showed a significant decrease in content (Mn) by P2K2 > P1 > K1 > P1 K1 in leaves; while, in seeds K1 >P1 > P2K2 > P1K1. respectively.

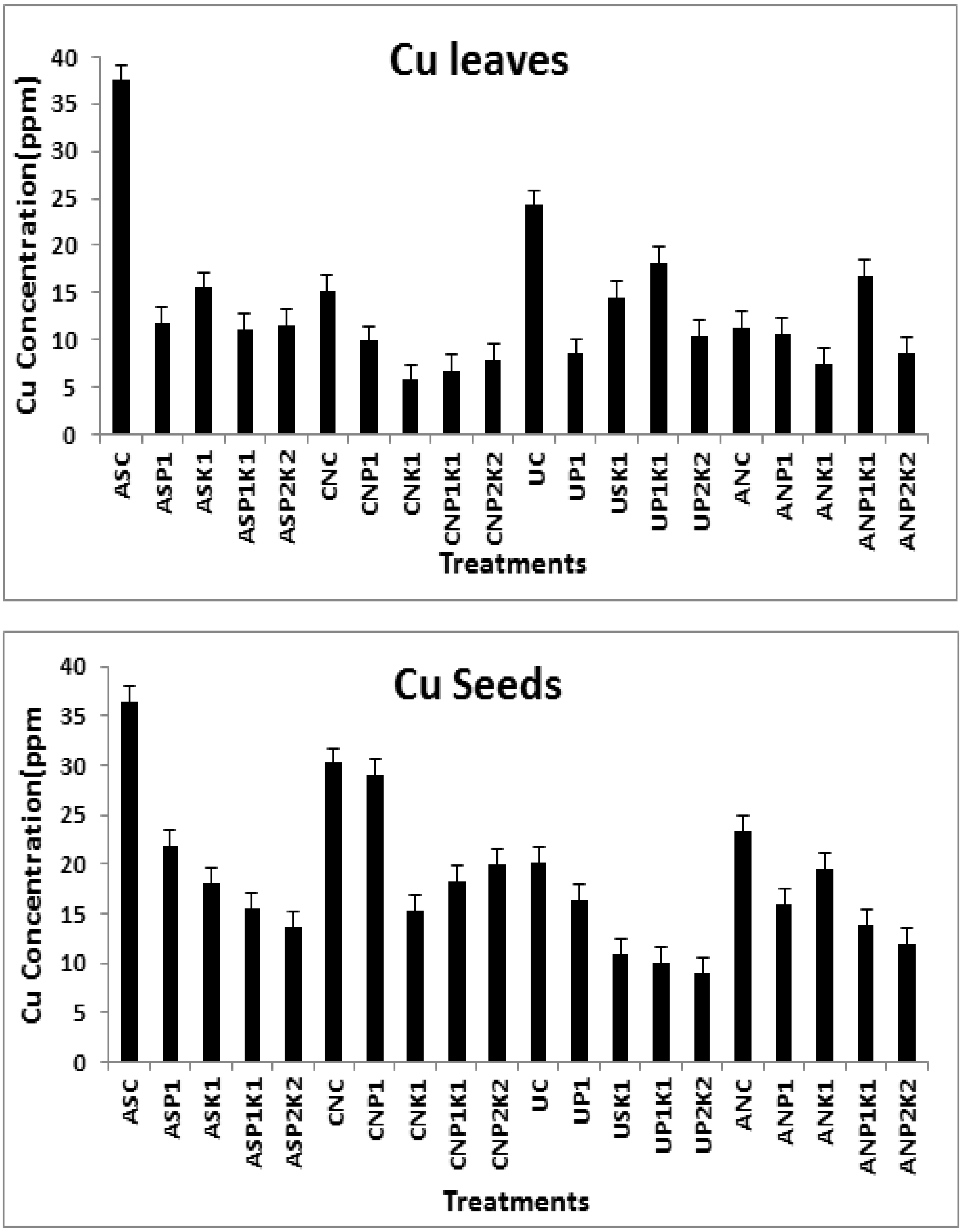
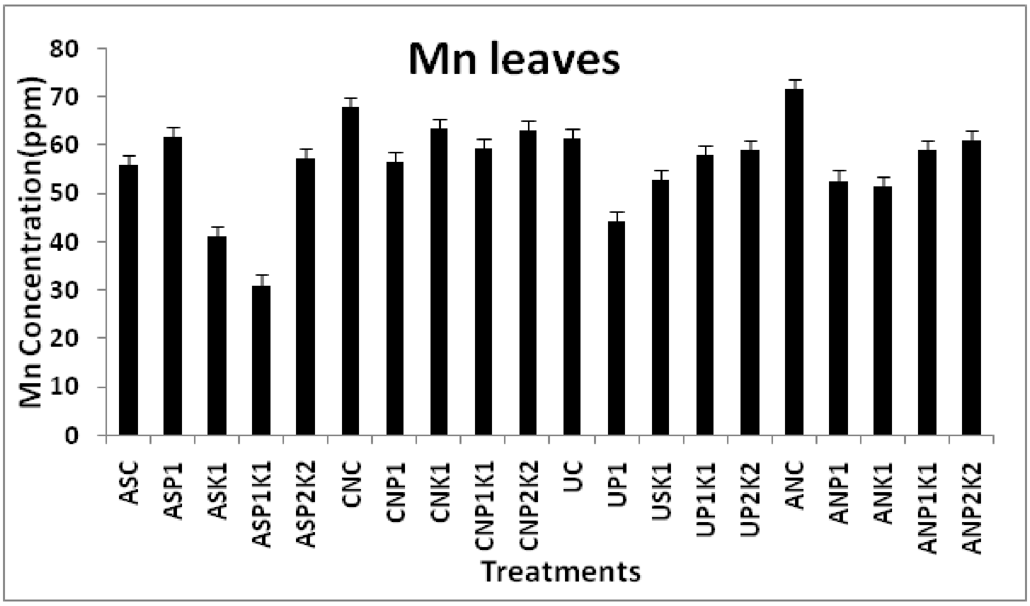


Fig. 2. Cu content in leaves and seeds of jojoba shrub



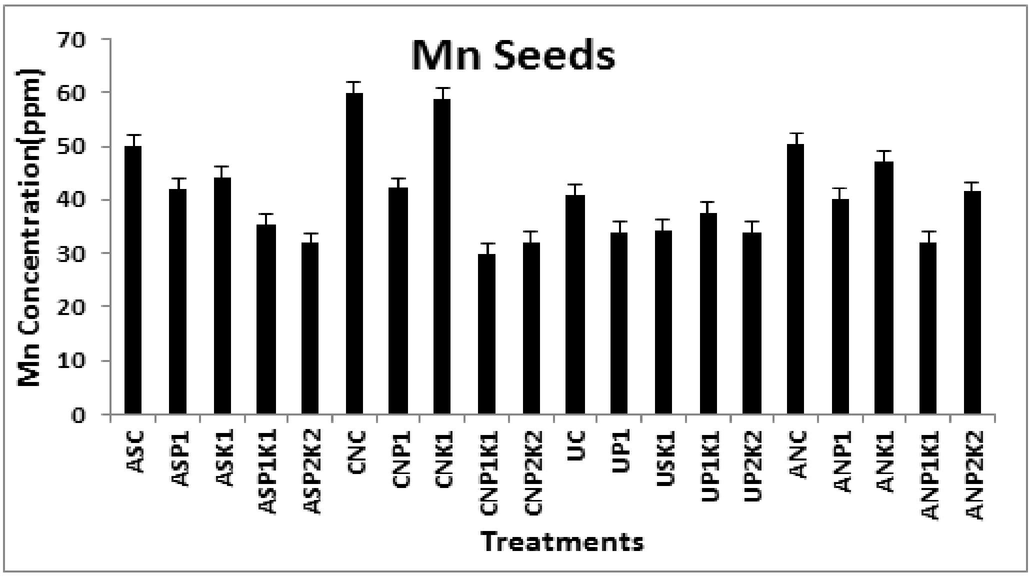
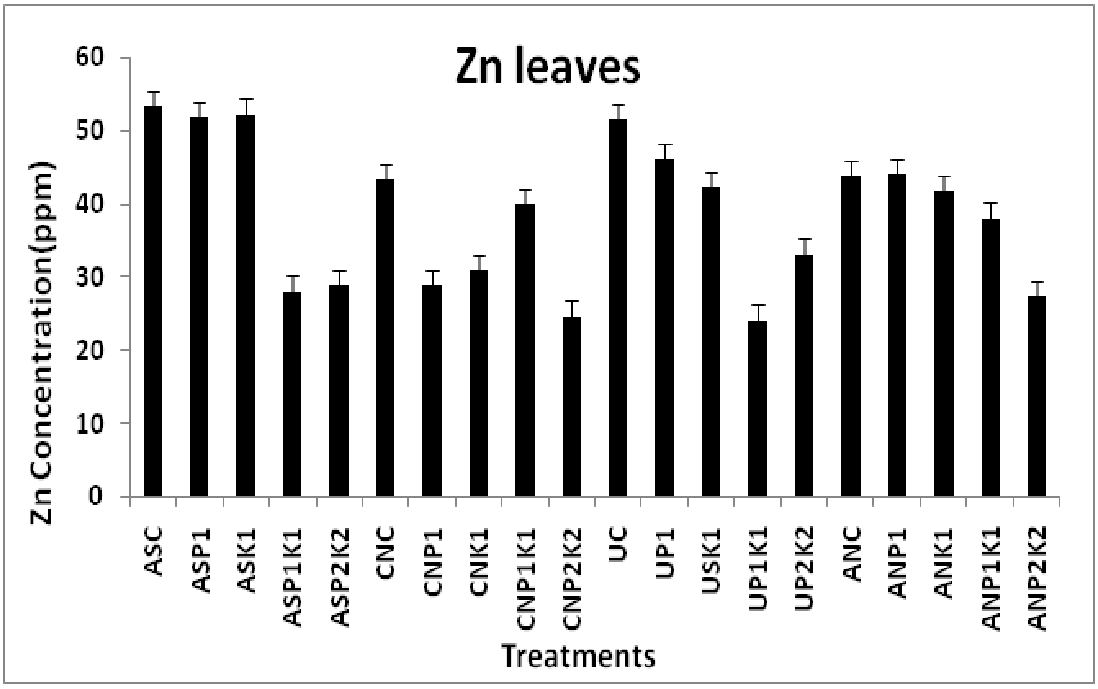


Fig. 3. Mn content in leaves and seeds of jojoba shrub

While the control treatment gave the highest accumulative in leave and seeds. Notice that Synergism interaction between CN only treatment and plant's uptake of Mn gave the highest accumulative (71.71 and 59.8ppm respectively) in leaves and seeds, there is also an antagonistic interaction between AS P1K1 source and Mn gave the lowest accumulative (31.17 ppm) in leaves. while, in seeds estimated at 29.8 ppm by CN only. The results showed also that Mn concentration in jojoba plants accumulated in leaves > seeds.

Zn content in leave and seeds (Fig. 4) was accumulated with As followed by, U and AN and CN gave the lowest data. Combinations of P K fertilizer treatments showed significantly decrease content (Zn) by P1 > K1 > P1 K1 > P2K2 in leaves; where, in seeds K1 > P1K1 > P1 > P2K2 respectively while the control treatment gave the highest accumulative in leave and seeds. Notice that Synergism interaction between AS only treatment and plant's uptake of Zn gave the highest accumulative (53.37 and 59.18 ppm respectively)in leaves and seeds. There is also an antagonistic interaction between U P1K1 source and Zn gave the lowest accumulative (24.14 ppm) in leaves. In seeds estimated at 29.94 ppm by CNP2K2. The results showed also that Zn concentration in jojoba plants accumulated in seeds > leaves.

Pb content in leaves and seeds (Fig. 5) was accumulated with CN followed by AN and AS, and U gave the lowest data. Combinations of P K fertilizer treatments showed a significant decrease in content (Pb) by P1>K1> P1 K1>P2K2 in leave and seeds; respectively while the control treatment gave the highest accumulative in leaves and seeds.



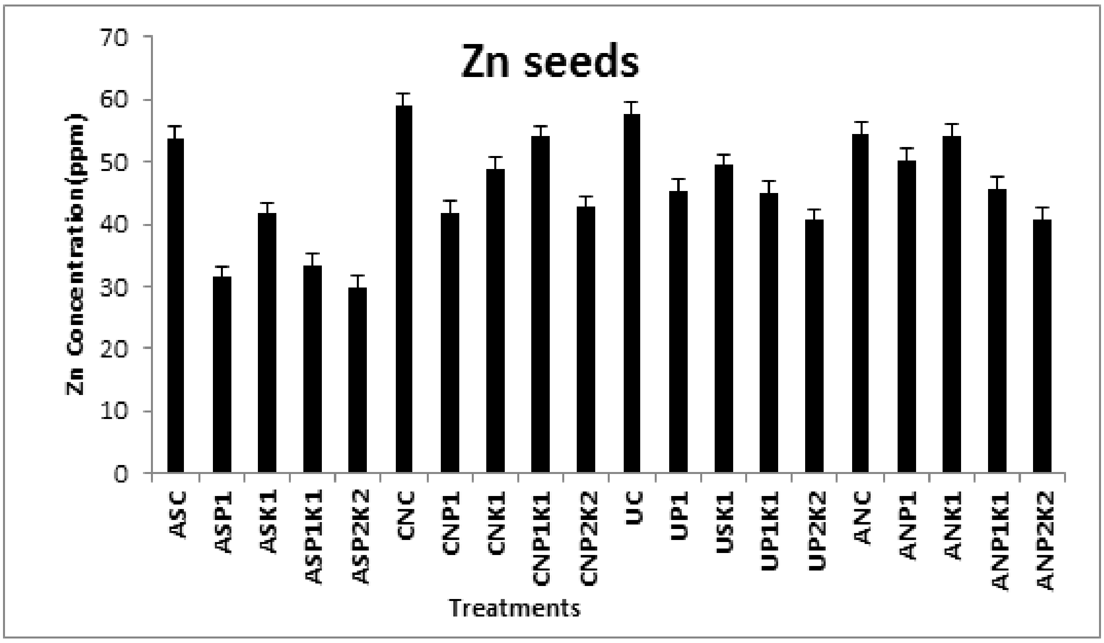
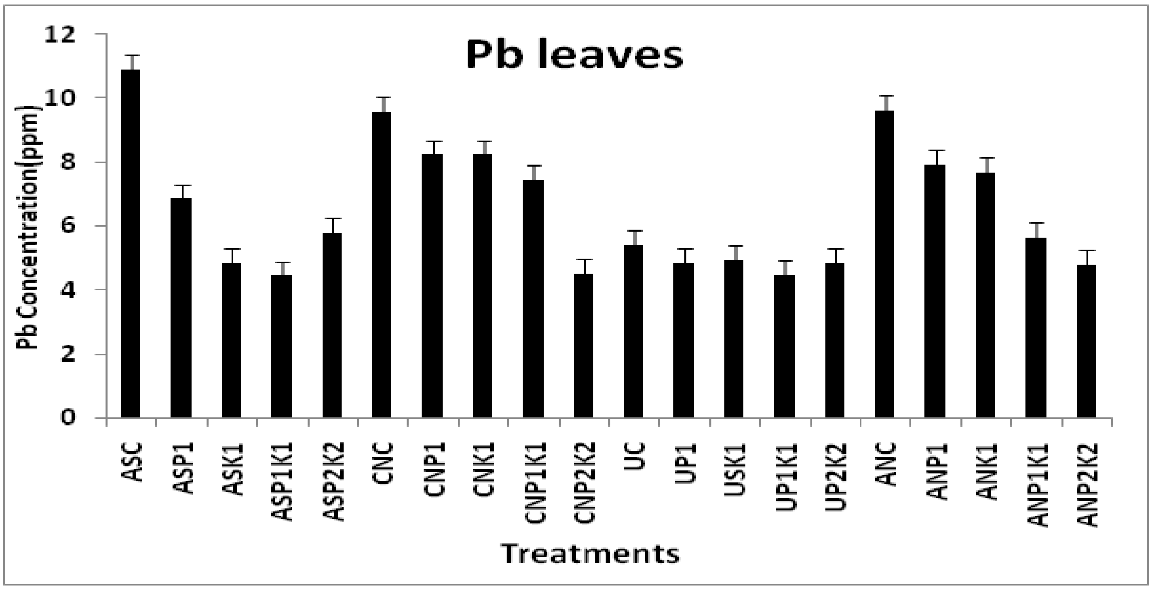


Fig. 4. Zn content in leaves and seeds of jojoba shrub



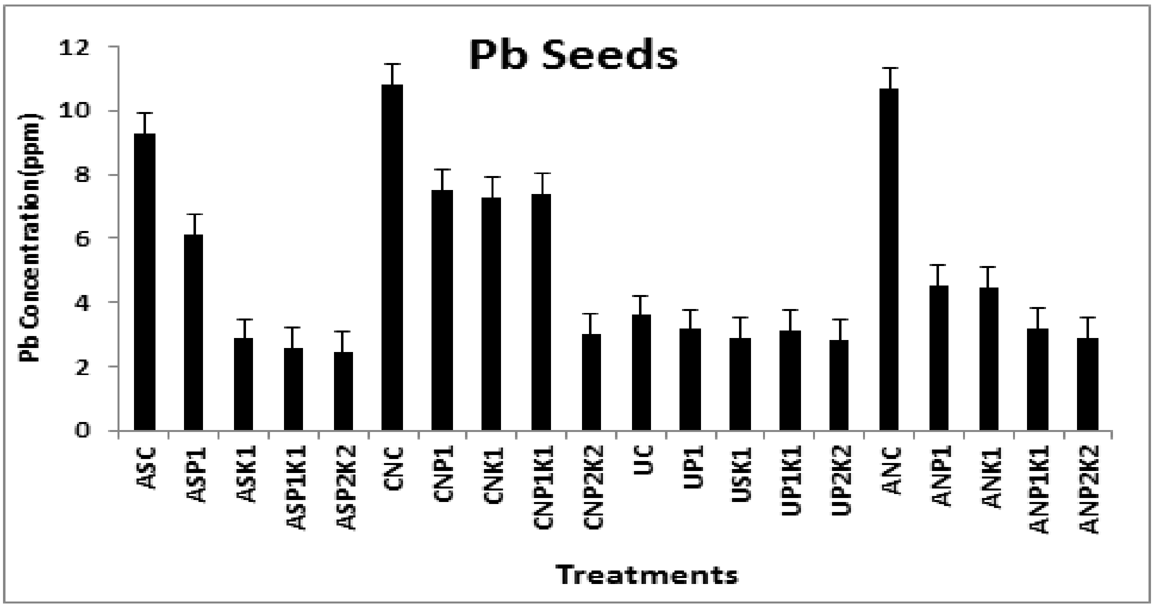


Fig. 5. Pb content in leaves and seeds of jojoba shrub

Notice that Synergism interaction between CN only treatment and plant's uptake of Pb gave the highest accumulative (10.91 and 10.81ppm, respectively) in leaves and seeds. There is also an antagonistic interaction between U P1K1 source and Pb gave the lowest accumulative (4.44 ppm) in leaves. where, in seeds estimated at 2.46 ppm by ASP2K2. The results showed also that Pb concentration in jojoba plants accumulated in leaves > seeds.

In view of the potential toxicity of these elements to plant, the current results indicate that the concentrations of Fe, Mn, Zn, Cu and Pb in seeds and leaves of jojoba plants, lower the normal ranges except Fe exceeded the normal ranges reported by (Kabata-Pendias and Pendias, 1992) and (Reeves and Baker, 2000). The bioavailability of heavy metals in jojoba plant might be increased due to the ionization in the aqueous phase in the soil which increases their reactivity and instability as earlier reported by Kumar & Chopra (2014). The previous results seemed to be supported by those obtained by Tawfik (2008) who showed that Faba bean plants irrigated with wastewater exhibited the highest levels of N, P, K, Ca, Na and S. It was reported that the safe values for Cu, Pb, Cd, Ni and Zn in fruit and vegetables recommended by the WHO/ FAO are Cu, Pb, Cd, Ni, Zn 40, 0.3, 0.2, 4 and 4.5 mg/kg, respectively, (Husain *et al.,* 1995).The present results showed that heavy metal accumulation was more in leaves than seeds, The accumulation of heavy metals in johoba was arranged in the following preference: Fe > Mn > Zn **>** Cu **>** Cr > Pb.

NPK availability in soil at the end of experiment

Table 5 shows the availability of N, P and K after completing the experiment were significantly increased as a result of nitrogen fertilization, AS treatment increased the nutrient availability (NPK) in soil followed by U and CN while AN gave the lowest data. The application of ASP2K2 gave significant available nutrients in soil at layer 0-30 cm by 101.67, 16.92 and 243.28 ppm for available N, P and K, respectively. The previous results seemed to be supported by those obtained by Shukry et al. (2013).

Heavy metals status of soil at the end of experiment

It is clearly to notice that from Table 6 that the highest value of available (Fe and zn) contents in soil solution at layer 0-30 cm was obtained from AN followed by U followed by AS fertilizer, and the lowest value from CN. On the other hand, the highest value of (Cu, Mn and Pb) contents was estimated by AS > AN > CN > U.

The interaction between nitrogen fertilization sources and the combination PK treatments significantly decreased heavy metals contents in soil solution. Generally, it was noticed a low availability of metals comparing with total soil content as in Table 6 which might be attributed to soil salinity. Usman et al. (2004) found that the mobility of heavy metals can be increased by the addition of sewage sludge. Slama et al. (2019) application of FMC treatments increased Zn,Cu, Pb and Cd accumulation in carrot and sugar beet plants compared to control. The previous results seemed to be supported by those obtained by Abdelrahman (2019).

TABLE 6. Soil available NPK and Heavy metals in soil at the end of the experiment

Factor A*	**AS**	**CN**	**U**	**AN**	**AS**	**CN**	**U**	**AN**
Factor B**		**N ppm**				**P ppm**		
Control	71.67f	51.67 h	75.00 ef	61.67g	5.09o	5.10o	6.37m	5.12o
P1	81.67de	71.67 f	78.67ef	81.67de	7.71g	6.43lm	7.39h	6.96j
K1	91.67bc	81.67de	86.67cd	87.67 cd	6.80k	6.12n	7.18i	6.18n
P1K1	96.67ab	86.67cd	95.00 ab	91.67bc	8.55e	6.52l	7.74g	8.21f
P2k2	101.67a	95.00 ab	101.67a	98.00ab	16.92a	8.93d	16.67b	11.21c
LSD0.5	A=3.494 B=3.409 A*B=7.009				A=0.0515 B=0.056 A*B=0.1126			
		K ppm				Fe ppm		
Control	102.49jk	98.98 jk	97.13 jk	92.50 k	884.02 b	872.62c	863.90e	894.51a
P1	129.69fgh	108.60ij	119.51hi	96.20 k	871.63 cd	855.80fg	856.04f	868.45 d
K1	159.10d	123.58gh	135.98ef	98.98 jk	881.39 b	868.43d	849.83hi	858.08f
P1K1	168.35d	165.76d	183.71c	135.05efg	819.90k	812.48l	846.59i	856.26 f
P2k2	243.28a	206.28b	203.50b	141.53e	780.63m	772.96n	839.91j	852.13 gh
LSD0.5	A=4.2534 B=4.1606 A*B=11.781				A=1.6889 B=1.8905 A*B=3.7710			
		Cu ppm				Mnppm		
Control	2.89a	2.41 d	0.79k	2.82b	17.33a	17.12b	9.08f	14.19e
P1	1.89e	1.79 f	0.71n	2.55c	15.84 c	14.85d	4.92m	8.02hi
K1	1.71	1.69h	0.68 o	1.11i	8.76 g	7.14j	4.34o	7.01j
P1K1	1.09 j	1.11i	0.56p	0.77l	8.17 h	5.81k	2.84p	5.51l
P2k2	0.74m	0.71n	0.35 q	0.67o	7.98 i	5.58l	1.75q	4.62n
	A=0.0092 B=0.0067 A*B=0.0151				A=0.1192B=0.0699 A*B=0.1720			
		Zn ppm				Pb ppm		
Control	104.61c	101.81g	105.26 a	106.25 b	2.80a	2.66b	1.89g	2.79a
P1	102.80 e	100.45j	103.93d	102.32f	2.46c	2.02e	1.48j	2.03e
K1	101.06h	100.35j	100.07i	100.74	2.09d	1.78 h	1.12m	1.94f
P1K1	100.31jk	98.67l	98.33m	100.08k	1.57i	1.09 n	1.09 n	1.38k
P2k2	95.19p	96.48 n	95.86o	98.56lm	1.25l	0.91p	0.85q	1.00o
LSD0.5	A=0.0811 B=0.1400 A*B=0.2629				A=0.0118 B=0.0105 A*B=0.0221			

* AS: ammonium sulfate, CN: calcium nitrate, U: urea, AN: ammonium nitrate

** Control: no application, P1:75kg$P_2O_5ha^{-1}$, P2: 150kg$P_2O_5ha^{-1}$, K1:60kgK_2Oha^{-1}, K2:120kgK_2Oha^{-1}.

Bioconcentration factors from soils to different plant tissues of jojoba plant

The Bioconcentration factors (BCF) calculated for heavy metal transfer from soils to different plant tissues of jojoba plant is shown in Table 7.

Bioconcentration factor (BCF) is an excellent indicator of elements accumulation capacity because it takes into account the ratio of elements concentration in the substrate and the plant (Zayed et al., 1998, Odjegba and Fasidi, 2004, Liu et al., 2009,Wu et al., 2010 and Eissa et al., 2017). The trends in the BCF for heavy elements in different plant tissues of jojoba plant were in the descending order of Cu > pb > Mn > Zn > Fe for BCF_{leave} and BCF_{seed} where their values (2.72, 1.08, 0.24, 0.21 and 0.18) and (2.64, 0.92, 0.22, 0.21 and 0.07), respectively. which is inconsistent with the findings of Liu *et al*. (2005). It may be noted that there are a noticeable difference in BCF values between leaves and seeds of jojoba plant because heavy metal uptake by plants depends on physiological character of their tissues. For other treatments, the trends of the bioconcentration factors in the jojoba tissues were different from that of the control treatment, that due to the different amounts and types of fertilizers BCF_{leave} of Cu, Pb, Mn, Fe and Zn were ranged between (15.06-0.05), (1.08-0.30), (0.49-0.13), (1.20-0.04) and (0.24-0.09) respectively. While BCF_{seed} of Cu, Pb, Mn, Zn and Fe were ranged between (16.80-0.04), (1.01-0.18), (0.45-0.10), (0.27-0.11) and (0.65-0.02) respectively.

Assessment of heavy metals risk in jojoba plant

The results of this study indicate that the average concentrations of Fe limits in the different parts of jojoba plant were (herbs 1045.1& seeds 632.5 ppm) above the permissible limit in plant is 20 ppm (FAO/WHO 1984). While for Mn, the permissible limit set by FAO/WHO (1984) in edible pants was 2 ppm. So, the average concentrations of Mn in different parts in jojoba plant were (herbs 56.5 & seeds 40.9 ppm) above 2 ppm. The average concentrations of Zn in the different parts of jojoba plant were (herbs 38.7 & seeds 45.9 ppm) above the permissible limit in plant is 27.4 ppm in edible pants (FAO/WHO 1984). On the other hand, it is below the WHO, s recommended limit of Zn in plants is 50 ppm (Shah et al., 2013). The permissible limits for Cu recommended for plants by WHO is 10 ppm (Hassan et al., 2012). So, the average concentrations of Cu in different jojoba plants were (herbs 13.2 & seeds 18.4 ppm)above the permissible limits according to WHO (Hassan et al., 2012). For Pb, the average its concentrations in different parts of jojoba plant are (herbs 6.56 & seeds 5.03 ppm) below the permissible limits of herbal medicine (10 ppm) as set by China, Malaysia, Thailand and WHO (WHO 2005). From that, the concentration of heavy metals in jojoba plant is acceptable. Because jojoba plant is not considered an edible plant, it is useful for cosmetics and lubricant industries, and biodiesel.

TABLE 7. Bioconcentration factors (BCF) of heavy metals in different plant tissues of jojoba shrubs

Factor A*	FactorB**	Fe		Mn		Zn		Cu		Pb	
		BCF_{leave}	BCF_{seed}	BCF_{leave}	BCF_{seed}	BCF_{leave}	BCF_{seed}	BCF_{leave}	BCF_{seed}	BCF_{leave}	BCF_{seed}
AS	Control	0.18	0.07	0.24	0.22	0.21	0.21	2.72	2.64	1.08	0.92
	P1	0.19	0.12	0.33	0.22	0.19	0.11	0.76	1.42	0.33	0.29
	K1	0.26	0.1	0.29	0.31	0.21	0.17	1.67	1.94	0.45	0.27
	P1K1	0.19	0.11	0.23	0.26	0.12	0.14	1.22	1.72	0.43	0.25
	P2k2	0.29	0.11	0.29	0.16	0.12	0.12	1.39	1.64	0.54	0.23
CN	Control	0.11	0.09	0.4	0.35	0.17	0.24	0.94	1.86	0.9	1.01
	P1	0.21	0.17	0.3	0.22	0.12	0.17	1.09	3.23	0.72	0.66
	K1	1.1	0.55	0.49	0.45	0.15	0.23	2.54	6.8	0.8	0.71
	P1K1	0.57	0.56	0.45	0.22	0.19	0.26	3.41	9.13	0.71	0.7
	P2k2	0.29	0.27	0.4	0.2	0.12	0.2	3.24	8.11	0.45	0.3
U	Control	0.88	0.65	0.46	0.31	0.24	0.27	15.06	12.47	0.5	0.33
	P1	1.2	0.62	0.37	0.28	0.23	0.22	8.79	16.8	0.48	0.31
	K1	0.05	0.07	0.23	0.15	0.16	0.18	1.37	1.04	0.32	0.18
	P1K1	0.09	0.05	0.24	0.16	0.09	0.17	1.08	0.59	0.3	0.21
	P2k2	0.05	0.02	0.18	0.1	0.11	0.14	0.05	0.04	0.32	0.18
AN	Control	0.06	0.04	0.19	0.13	0.2	0.25	0.34	0.7	0.7	0.77
	P1	0.04	0.02	0.13	0.1	0.22	0.25	0.39	0.58	0.58	0.33
	K1	0.09	0.05	0.18	0.16	0.15	0.19	0.34	0.91	0.57	0.33
	P1K1	0.11	0.07	0.24	0.13	0.13	0.16	0.84	0.69	0.38	0.21
	P2k2	0.09	0.04	0.25	0.17	0.13	0.19	0.55	0.76	0.3	0.18

* AS: ammonium sulfate, CN: calcium nitrate, U: urea, AN: ammonium nitrate

** Control: no application, P1:75kg$P_2O_5$$ha^{-1}$, P2: 150kg$P_2O_5$$ha^{-1}$, K1:60kg$K_2O$$ha^{-1}$, K2:120kg$K_2O$$ha^{-1}$.

Assessment of some elements risk indices

The risk indices were explicit to investigate the contamination degree of elements in the studied soils. For the risk indices were enrichment factor (EF), If the EF is higher than 1, the metal concentration in the soil sample will enrich relative to the average of continental crust and the source of the metal in the topsoil is likely to be anthropogenic which resulted from irrigated with industrial wastewater. On the other hand, when the EF values are less than 1, this indicates that the metal concentration is not enriched and may be related to the natural source. If the EF values are equal to 1, this indicates that metal concentration and its reference value are the same (Swarnalatha et al., 2015). It is clear that in table (8) there is changes enrichment risk for Mn, Zn, Cu and Pb. The highest values of EF were observed with Zn followed by Pb > Mn> Cu with AS, CN and U treatments but with AN treatment, the highest values of EF were observed with Zn followed by Pb > Cu > Mn. Clearly. From these results the enrichment factor is different by different types of fertilizer.

The interpretation of I_{geo} values is listed in Table (9). The contamination levels are classified into six categories from uncontaminated to extremely contaminated soil based on I_{geo} values that may be ranged from 1 to 5. Table (8) shows that the I_{geo} values for studied elements. The studied elements presented I_{geo} values less than zero. Accordingly, contamination of Fe, Mn, Zn, Cu and Pb according to I_{geo} is considered uncontaminated/moderately contaminant.

Table (10) shows the interpretation of contamination factor (CF) values. The high values of CF values were observed with Zn only. Contamination factor of Fe, Mn, Zn, Cu and Pb is considered low degree of contamination.

TABLE 8. Some elements risk indices in studied soil

Factor A*	FactorB**	Fe		Mn			Zn			Cu			Pb		
		I_{geo}	CF	I_{geo}	EF	CF	I_{geo}	EF	CF	I_{geo}	EF	CF	I_{geo}	EF	CF
AS	Control	-3.37	0.14	-2.74	1.55	0.23	0.12	11.26	1.63	-3.10	1.20	0.17	-2.78	1.51	0.22
	P1	-4.15	0.08	-3.07	2.11	0.18	0.25	21.08	1.79	-2.94	2.31	0.20	-1.74	5.32	0.45
	K1	-4.36	0.07	-3.47	1.85	0.14	0.07	21.51	1.57	-3.67	1.62	0.12	-2.68	3.20	0.23
	P1K1	-4.49	0.07	-3.56	1.91	0.13	-0.01	22.40	1.49	-3.70	1.73	0.12	-2.72	3.41	0.23
	P2k2	-4.81	0.05	-3.03	3.45	0.18	0.04	28.99	1.55	-3.84	1.96	0.10	-2.67	4.42	0.24
CN	Control	-3.32	0.15	-3.21	1.08	0.16	0.10	10.72	1.61	-2.87	1.37	0.21	-2.70	1.54	0.23
	P1	-4.54	0.06	-3.05	2.79	0.18	0.04	23.82	1.54	-3.72	1.76	0.11	-2.60	3.83	0.25
	K1	-6.51	0.02	-3.61	7.47	0.12	-0.13	83.51	1.37	-5.72	1.73	0.03	-2.74	13.63	0.22
	P1K1	-6.49	0.02	-3.58	7.51	0.13	-0.14	81.72	1.36	-5.88	1.53	0.03	-2.71	13.78	0.23
	P2k2	-5.38	0.04	-3.33	4.14	0.15	-0.15	37.34	1.35	-5.59	0.86	0.03	-2.77	6.09	0.22
U	Control	-6.34	0.02	-3.58	6.78	0.13	-0.12	74.66	1.38	-6.20	1.10	0.02	-2.67	12.75	0.24
	P1	-6.71	0.01	-3.74	7.81	0.11	-0.19	91.32	1.31	-6.93	0.85	0.01	-2.76	15.41	0.22
	K1	-3.45	0.14	-2.79	1.58	0.22	0.20	12.55	1.72	-3.49	0.97	0.13	-2.14	2.49	0.34
	P1K1	-3.15	0.17	-2.73	1.34	0.23	0.15	9.87	1.67	-2.80	1.27	0.21	-2.22	1.90	0.32
	P2k2	-2.36	0.29	-2.29	1.05	0.31	0.37	6.61	1.93	0.77	8.74	2.56	-2.18	1.13	0.33
AN	Control	-2.00	0.38	-2.06	0.96	0.36	-0.07	3.81	1.43	-1.82	1.13	0.43	-2.32	0.80	0.30
	P1	-2.27	0.31	-2.00	1.21	0.38	-0.22	4.15	1.29	-2.12	1.11	0.35	-2.35	0.95	0.29
	K1	-2.83	0.21	-2.45	1.30	0.27	0.27	8.59	1.81	-2.45	1.30	0.27	-2.35	1.40	0.30
	P1K1	-3.53	0.13	-2.71	1.76	0.23	0.34	14.62	1.90	-2.57	1.95	0.25	-2.20	2.52	0.33
	P2k2	-2.94	0.19	-2.69	1.19	0.23	-0.16	6.90	1.34	-2.92	1.02	0.20	-2.13	1.76	0.34

TABLE 9. The geoaccumulation index (I_{geo}) for contamination levels in soil

I_{geo}	Class I_{geo} values	Contamination level
0	$I_{geo} \leq 0$	Uncontaminated
1	$0 < I_{geo} < 1$	Uncontaminated/moderately contaminated
2	$1 < I_{geo} < 2$	Moderately contaminated
3	$2 < I_{geo} < 3$	Moderately/strongly contaminated
4	$3 < I_{geo} < 4$	Strongly contaminated
5	$4 < I_{geo} < 5$	Strongly/extremely contaminated
6	$5 < I_{geo}$	Extremely contaminated

TABLE 10. The interpretations of contamination factor (CF) values

CF	C_d	Description
CF <1	C_d<7	Low degree of contamination
1 < CF < 3	7 < C_d< 14	Moderate degree of contamination
3 < CF < 6	14 < C_d<28	Considerable degree of contamination
CF > 6	C_d> 28	Very high degree of contamination

Conclusion

Ammonium sulfate (AS) followed by ammonium nitrate (AN) significantly surpassed the other nitrogen sources concerning their effect on all the studied vegetative growth and yield parameters of jojoba shrubs. Also, P2K2 showed the highest significant values of growth and yield parameters. The highest significant treatment was the application of nitrogen as AS in the presence of P2K2 where significantly increased all growth and yield parameters while significantly decreased trace elements and heavy metals contents in soil solution.AS treatment increased the nutrient availability (NPK) in soil followed by U and CN while AN gave the lowest data. Bioconcentration factor (BCF) for heavy metals in leaves and seeds of jojoba shrub showed a trend in the following order; Cu > pb > Mn > Zn > Fe.

Author contribution

This study was designed and implementedby authors,where all authors contributed in writing the manuscript, interpreting information presented and have read and agreed to the version of the manuscript.

Consent for publication

All authors declare their consent for publication.

Conflicts of Interest

The authors declare that there is no conflict of interes

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References

Abdelrahman, H.(2019) Chelate Induced Redistribution of Pb and Zn Fractions in Contaminated Soils and Implications on Phytoremediation. *Egypt. J. Soil Sci.* **59** (2), 145- 155.

Abrahim, G.M.S. and Parker, R.J. (2008) Assessment of heavy metal enrichment factors and the degree of contamination in marine sediments from Tamaki Estuary, Auckland, New Zealand. Environ. Monit. Assess. 136, 227-238. http:// dx.doi.org /10.1007/ s10661-007-9678-2.

A.O.A.C (1990) Official methods of analysis of the Association of Official Analytical Chemists. Vol. 1. In: The association.

Adams, J.A., Johnson, H.B., Bingham, F.T. and Yermanos, D.M.(1977) Gaseous exchange of jojoba measured with double isotope porometer, related to water stress, salt stress and nitrogen deficiency. *Crop Sci.* **17**,11-15.

Ashraf, M.Y. and A.H. Khan. (1993) Effect ofNaCl on nitrogen status of sorghum. In: *Current Development in Salinity and Drought Tolerance of Plants*. (Naqvi, S.S.M., R. Ansari, T.J. Flower, A. R. Azmi, Eds) pp. 84-88.

Bashir, M.A., M. Ahmed and M.A. Anjum, (2006) Propagation of six promising jojoba strains through veneer grafting. *Inter. J. Agric. & Biol.,* **8** (4), 482-484.

Bashir, M.A., M.A. Anjum and H. Rashid, (2007) In vitro root formation in micropropagated shoots of jojoba (*Simmondsia chinensis*). *Biotech.,* **6** (3),465-472.

Benzioni A, Ventura M (1998) Effect of phosphorus concentration in irrigation water on the development of jojoba cuttings. *J. Plant Nutr.* **21**(12), 2697-2706.

Benzioni, A. and Dunstone, R.L. (1986) Jojoba: Adaptation to environmental stress and implications for domestication. *Quarterly Rev. Biol.* **61**,177-179.

Benzioni, A.and Nerd, A. (1985) Effects of irrigation and fertilization on vegetative growth and yield of jojoba in relation to water status of plant. Publication, *Applied Res. Inst., BenGurion Univ. of Negev.* **44**, 1-18.

Chen, C.W., Kao, C.M., Chen, C.F. and Di Dong, C. (2007) Distribution and accumulation of heavy metals in the sediments of Kaohsiung Harbor, Taiwan. *Chemosphere,* **66,** 1431e1440. http://dx.doi.org/10.1016/j.chemosphere.2006.09.030.

Chen, H., Teng, Y., Lu, S., Wang, Y., and Wang, J. (2015) Contamination features and health risk of soil heavy metals in China. *Science of The Total Environment,* 512-513, 143-153. doi:10.1016/j.scitotenv.2015.01.025.

Eissa, D., Abou-Shady, A., Ismaeil, S. and Bahnasawy, N. (2017) Distribution and Mobility of Vanadium in Cultivated Calcareous Soils and Some Food Chain Crops. *Egypt. J. Soil Sci.* **57** (4)385-392.

El-Dissoky, R.A. (2019) Mixed and Conventional Nitrogen Fertilizers Impacts on Yield, Quality and Nutrient Uptake by Potato. *Egypt. J. Soil. Sci.* Vol. **59** (3), 259-274

El-Sayed, S.A.M. (1998) Use of sewage sludge and farmyard manure as N-fertilizer in New Valley Governorate. *Egypt. J. Soil Sci.* **38**, 1-19.

FAO/WHO (1984) Contaminants. In Codex Alimentarius, vol XVII, 1st edn 1. FAO/WHO, Codex Alimentarius Commision, Rome.

Francis, George, Raphael Edinger, and Klaus Becker (2005) “A concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India: need, potential and perspectives of Jatropha plantations.” *Natural Resources Forum*. Vol. **29**. No. 1. Oxford: Blackwell Publishing, Ltd.

Gendy, A. S.H., Hussein, A.H., Mahmoud,A. A. and Mohamed, H.F. Y. (2013) Effect of Nitrogen Sources, Bio-Fertilizers and Their Interaction on the Growth, Seed Yield and Chemical Composition of Guar Plants. *Life Sciences,* **10**, 389-402.

Ghosh M, Singh SP (2005) A comparative study of cadmium phytoextraction by accumulator and weed species. *Environ Pollut.* **133**, 365-371.

Hakanson, L. (1980) An ecological risk index for aquatic pollution control. A sedimentological approach. *Water Res.* **14** (8), 975-1001.

Hassan Z, Anwar Z, Khattak KU, Islam M, Khan RU and Khattak JZK (2012) Civic pollution and its effect on water quality of river Toi at district Kohat, NWFP. *Res. J. Environ Earth Sci.* **4** (3), 334-339.

Hedia, R.M.R. (2014) Characterization Changes of Heavy Metals Contents and Fractions in Sewage Sludge from Sirt Wastewater Treatment Plant, Libya. *Egypt. J. Soil Sci.* **54**, 195-208.

Husain, Z. Baroon, M. Al-khalafawi, T. Al-Ati, and W. Sawaya (1995) Toxic metals in imported fruits and vegetables marketed in Kuwait. *Environment International*, **21**(6) 803-805.

Jackson MLR (2005) Soil chemical analysis: advanced course. UW-Madison Libraries Parallel Press.

Jongschaap, R.E.E., Corr´ e, W., Bindraban, P.S. and Brandenburg, W.A. (2007) Claims and Facts on Jatropha curcas L., Global Jatropha curcas evaluation, breeding and propagation programme; Report 158, 42 pages, Plant Research International Wageningen UR; 2007.

Khan, A.H., M.Y. Ashraf and A.R. Azmi. 1990. Effect of NaCl on growth and nitrogen metabolism of sorghum. *Acta Physiol. Plant.,* **12**, 233-238.

Khattab E.A., Afifi, M.H. and Gehan A. Amin (2019) Significance of nitrogen, phosphorus, and boron foliar spray on jojoba plants *Bulletin of the National Research Centre* (2019) **43**, 66.

Liu H.Y., Probst A., Liao B.H. (2005) Metal contamination of soils and crops affected by the Chenzhou lead zinc mine spill (Hunan, China). *Sci. Total Environ.,* **339**, 153-166.

Liu, Z.L., He, X.Y., Chen, W., Yuan, F.H., Yan, K. and Tao, D.L. (2009) Accumulation and tolerance characteristics of cadmium in a potential hyperaccumulator— Lonicera japonica Thunb. *J. Hazard. Mater.* **169**, 170-175.

Muller, G. (1969) Index of geoaccumulation in sediments of the Rhine River, *J. Geol.* **2** , 108-118.

Nadimi-Goki Mandana, Mohammad Wahsha, Claudio Bini , Yoichiro Kato, Gilmo Vianello and Livia Vittori Antisar (2014). Assessment of total soil and plant elements in rice-based production systems in NE Italy. *Journal of Geochemical Exploration,* **147**, 200-214.

Nasr, F. A., El-Shafai, S. A., Abdelfadil, A. S., Ibrahim, H. S. and Hemdan, B. A. (2019) Potential use of treated domestic sewage for cultivation of biofuel crops in Egypt. *International Journal of Environmental Science and Technology* **16,** 7433-7442.

Nerd, A. and Benzioni, A. (1988) Effect of water status, genetic background and fertilization on flowering of jojoba. *Advances in Hort. Sci.* **2**, 45-51.

Odjegba, V. J. and Fasidi, I. O. (2004) Accumulation of trace elements by Pistia stratiotes: implications for phytoremediation. *Ecotoxicology*. **13**, 637-646.

Osman, H.E., Abo Hassan, A.A.andSammarae, S.M. (2012) Jojoba (Simmondsia chinesis (Link) Schneider): A potential shrub in Arabian Desert. J.KAU: Met., *Env., Arid Land Agric*. **8**, 85-96.

Page, A.L., R.H. Miller and D.R. Keeney (1982) In "Methods of Soil Analysis". Part2: Chemical and Microbiological Properties. Second edition. *Agronomy J.* **9**, 2, Am. Soc. Agron. Inc., Soil Sci. Soc. Am. Inc. Pub. Madison, Wisconsin, USA.

Reyes, D.M., Stolzy, L.H. andLabanauskas, C.K. (1977) Temperature and oxygen effects in soil on nutrient uptake in Jojoba seedlings. *Agron. J.* **69**,647-650.

Rudnick, R. and Gao, S. (2004) Composition of the continental crust. In: Rudnick, R. (Ed.), *The Crust.* Elsevier Ltd, UK, pp. 1-64.

Shah A, Niaz A, Ullah N, Rehman A, Akhlaq M, Zakir M and Khan MS (2013) Comparative study of heavy metals in soil and selected medicinal plants. *J. Chem.* 1-5.

Shukry W.M., Al-Hawas ,G.H. S. 1, Al-Moaik R. M.S. 1 and. El-Bendary, M. A. (2013) Effect of petroleum crude oil on mineral nutrient elements and soil properties of jojoba plant (S I M M O N D S I A CHINENSIS) *Acta Botanica Hungarica* **55** (1–2),117-133,

Snedecor, G.W. and W.G. Chochron, (1992) Statistical methods. 8th ed., Iowa State Univ. Press, Iowa, USA.

Swarnalatha, K., Letha, J., Ayoob, S., and Nair, A.G. (2015) Risk assessment of heavy metal contamination in sediments of a tropical lake. *Environmental Monitoring and Assessment*, **187**, 322. doi:10.1007/s10661-015-4558-7.

Ure, A. M. (1995) Methods of analysis for heavy metals in soils. In: *Heavy metals in soils, Alloway*, B. J., Blacke Academic and Professional, an imprint of Chapman & Hall, Wester cleddens Road, Bishopbriggs, Glasgow G642NZ,UK.,58-102.

WHO (2005) Quality control methods for medicinal plant materials. WHO, Geneva.

World Health Organization (WHO) and Food and Agriculture Organization (FAO), (1996) "Codex general standard for contaminants and toxins in foods," Joint FAO/WHO joint food standards programme, Codex Alimentarious commission, Rome, Italy,

World Health Organization (WHO) and Food and Agriculture Organization (FAO), (2013) Geneva, Switzerland,. Tech. Rep., "Guidelines for the safe use of wastewater and food stuff" Report of the joint WHO/FAO Volume 2 no. 1.

World Water Development Report (2014) Volume 1 (water and energy) and volume 2 (facing the challenges).

Wu, F. Z., Yang, W. Q., Zhang, J. and Zhou, L. Q. (2010). Cadmium accumulation and growth responses of a poplar (Populus deltoids × Populus nigra) in cadmium contaminated purple soil and alluvial soil. *J. Hazard. Mater.* **177**, 268-273.

Yermanos, D.M. (1982) Jojoba: Out of the ivory tower and into the real world of agriculture. Annual Report, Agron. Dept., UCR, Riverside, California, USA, p. 101.

Zayed, A., S. Gowthaman and N. Terry (1998) Phytoaccumulation of trace elements by wetlands plants: *Duckweed. J. Environ. Qual.,* **27**, 715-721.

نمو وإنتاجية نبات الجوجوبا تحت التسميد بالعناصر الكبرى والري بمياه الصرف الصناعي

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تم إجراء تجربة حقلية على مدى موسمين زراعيين متتاليين لدراسة تأثير إضافة العناصر الكبرى على سلوك المعادن الثقيلة ، ونمو وإنتاجية شجيرات الجوجوبا المنتجة البالغة من العمر ٦ سنوات المنزروعة ، في أرض رملية والمروية بمياه صرف صناعى بمزرعة خاصة بالوادى الأسيوطى بمحافظة أسيوط . تم تنفيذ التجربة بتصميم قطاعات كاملة العشوائية بنظام القطع المنشقة مرة واحدة وكان العامل الرئيسي هو مصادر النيتروجين المختلفة (مثل اليوريا ، كبريتات الأمونيوم ، نترات الأمونيوم ونترات الكالسيوم بمعدل ٢٤٠ كجم/هكتار ، بينما تم تخصيص العامل تحت الرئيس لخمس توليفات من سماد الفوسفور والبوتاسيوم على النحو التالى (عدم إضافة (الكنترول) ، الفوسفور بمعدل ٧٥كجم فو٢أ٥/هكتار ، البوتاسيوم بمعدل ٦٠كجم بوا/هكتار ، ٧٥كجم فو٢أ٥ + ٦٠كجم بوأ/هكتار ، ١٥٠كجم فو٢أ٥ + ١٢٠كجم بوأ/هكتار). أشارت النتائج إلى أن كبريتات الأمونيوم يليها نترات الأمونيوم تفوقت بشكل معنوى على مصادر النيتروجين الأخرى فيما يتعلق بتأثيرها على جميع قياسات النمو الخضري وإنتاجية شجيرات الجوجوبا. كما أظهرت التوليفة (١٥٠كجم فو٢أ٥ + ١٢٠كجم بوأ/هكتار) أعلى قيم معنوية لقياسات النمو والإنتاجية تحت الدراسة. وكانت المعاملة الأكثر معنوية هي إضافة النيتروجين فى صورة كبريتات أمونيوم مع التوليفة (١٥٠كجم فو٢أ٥ + ١٢٠كجم بوأ/هكتار) حيث زادت بشكل معنوى كل قياسات النمو وإنتاجية شجيرات الجوجوبا ، بينما انخفض بشكل معنوى محتوى العناصر الصغرى والعناصر الثقيلة الميسرة فى محلول التربة. وأعطت المعاملة بكبريتات الأمونيوم يليها المعاملة باليوريا ونترات الكالسيوم أعلى قيم من العناصر الكبرى(النيتروجيبن والفوسفور والبوتاسيوم) الميسرةفى محلول التربة بينما أعطت المعاملة بنترات الأمونيوم أقل القيم. كما أظهر معامل التركيز الحيوى للعناصر الثقيلية فى أوراق وبذور شجيرات الجوجوبا الترتيب التالى: النحاس > الرصاص > المنجنيز > الزنك > الحديد.