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EFFECT OF AGRICULTURAL TREATMENTS ON *Jatropha curcas* GROWN ON AEOLIAN DEPOSITS AT TOSHKA, WESTERN DESERT, EGYPT

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ABSTRACT

Experiment was conducted during two consecutive years (2009 & 2010) in order to study "Effect of some agricultural treatments on Jatropha curcas cultivated under Aeolian deposits" at Toshka Research Station, of the Desert Research Center (DRC) in Aswan. The experiment conducted in randomized blocks with split-split plot design. The studied treatments were three: drip irrigation 12, 8, and $4Lh^{-1}$ (main plot), nitrogen (sub plot) with rates of 30, 60 & 90 $kgfed^{-1}$ and sulfur (sub-sub plot) with rates of 15 and 30 $kgfed^{-1}$. Each treatment was replicated three times. There was a reference treatment of no-N, no-S and irrigated by 4 Lh^{-1}).

Soil moisture (Saturation percent), temperature, acidity, salinity, cation exchange capacity, organic matter, and available N, P and K) were determined. Growth characteristics of plant height, stem diameter, crown cover and crown volume were also determined. Fruits yield/tree, fruits yield/fed, seed yield/tree, seed yield/fed, oil yield/fed and biodiesel yield l/fed) were also determined. Content of oil, protein in seeds, as well as NPK uptake were also determined.

Jatropha shrubs, which were irrigated and treated with nitrogen and sulfur, played an important role in improving soil physical and chemical characteristics. There was a significant increase with increasing of irrigation, nitrogen and sulfur on both vegetative and yield characteristics and yield of seeds, contents of seed oil and protein, and uptake of nitrogen, phosphorus and potassium. No significant differences were found in the effect of two rates of irrigation 12 and $8Lh^{-1}$) in most vegetative growth and yield characteristics of jatropha shrubs. Generally, the highest values for both vegetative growth and yield characteristics of jatropha shrubs were found at the application rate of 30kg of S under 90kg of N at the irrigation rate $12lh^{-1}$.

Keywords: Aeolian deposits, Jatropha shrubs, irrigation rates, Nitrogen and Sulfur fertilization

INTRODUCTION

Jatropha (*Jatropha curcas* L.) is a monoecious perennial belonging to the Euphorbia family. Seeds contain 35-40% oil. Oil cake of jatropha seed contains 3.2-4.4% N, (Oliveira and Dias, 2007). It grows on well-drained well-aerated soils and is well adapted to marginal soils with low nutrient contents. In many African countries, it is grown as a live fence and can be used to reclaim eroded areas. It has a high yield in oil, which can be used as fuel for diesel engines as well as for medical and insecticidal purposes (FACT Foundation, 2006).

The Jatropha shrubs have been introduced into Egypt, and researches are being conducted regarding adaptability of this plant under Egyptian conditions.

The nitrogen and sulphur requirements of crops are closely related, because both nutrients are required for protein synthesis. Sulphur is involved in the synthesis of chlorophyll and is also required for the synthesis of oil

(Marschner, 1986). The shortage in sulphur supply for crops decreases the N-use efficiency of fertilizers (Ceccoti, 1996). Consequently, the poor efficiency of N caused by insufficient S needed to convert N into biomass production may increase N losses from cultivated soils (Malhi *et al*., 2007). S fertilizer application also improves N-use efficiency and thereby maintains a sufficient oil level and fatty acid quality (Fismes *et al*., 2000).

Water is a major constituent of tissue, a reagent in chemical reaction, a solvent for translocation of metabolites and minerals within plant and is essential for cell enlargement through increasing turgor pressure. Water deficits disrupts physiological processes associated with growth are affected and under severe deficits, death of plants may result. Farahat (1990) in study on *Schinus molle, Schinus terbinthifolius* and *Myoporum ocminatum,* Mazher *et al.* (2010) on *Jatropha curcas* L seedlings, found that plant height, stem diameter and fresh and dry weight of leaves, stem and root decreased with prolonging the water intervals.

Desert environment, such as Toshka region, is characterized by extreme arid climate associated with mechanical weathering. This leads to processes of exfoliation, splitting and crushing of soil materials which lead to transporting the deposits by wind. The decisive factor which plays a fundamental role in this desert environment is the wind speed.

The present study was undertaken to evaluate the effect of various combinations of N and S fertilizers with different irrigations on growth development, seed yield and oil content of *Jatropha* grown on the aeolian deposits at Toshka.

MATERIALS AND METHODS

Two experiment were carried out during two successive years (2009 and 2010) to study the effect of some agricultural treatments on jatropha grown on aeolian deposits at the Experimental Farm (well No.80), Desert Research Center (DRC), at Toshka area which located at 22 km north-west of Abu Simbel City, belong to Aswan Governorate, Western Desert (22°32′16″N, 31°30′40″E**)**. Soil particle distribution and soil chemical properties before the experiment are shown in Table 1a,b.

Table1a: Soil particles size distribution of field experiment.

Soil depths in cm	Soil particles size distribution %				Soil texture
	Coarse sand	Fine sand	Silt	Clay	
0-30	78.94	18.09	2.95	0.02	Sand
30-60	77.23	19.97	2.77	0.03	Sand

Table1b: Soil chemical properties of field experiment.

Soil depth in cm		0-30	30-60			0-30	30-60
pH	**soil paste extraction**	7.62	7.46	**Cation mel^{-1}**	**Ca^{+2}**	7.3	6.7
EC dSm^{-1}		2.95	2.82		**Mg^{+2}**	4.6	4.3
CEC Cmolc kg^{-1}		2.70	2.35		**Na^{+}**	17.1	15.5
SAR		7.01	6.61		**K^{+}**	1.5	1.6
O.M. %		0.09	0.05	**Anion mel^{-1}**	**HCO^{-3}**	1.2	1.1
Available N ppm		59.50	61.70		**SO_4^{-2}**	10.6	9.1
					Cl^{-}	18.8	17.9

CEC: Cation Exchange Capacity O.M.: Organic Matter SAR: Sodium Adsorption Ratio

The climatologically records of Abo Sembel Meteorological Station, the nearest to the study area, during the periods from 2000-2009 years are shown in Table 2. From the Table No.1 the average monthly temperature varied between 16.80 in January and 35.50 in August.

Experiment was designed in a randomized block design factorial (split-split plot) with three replicates. The main plots were for drip irrigation (12, 8 and $4Lh^{-1}$), the sub plots were for N fertilizer (30, 60 and 90 $kgfed^{-1}$) and the sub-sub plots were for S fertilizer (15 and $30kgfed^{-1}$).

Table2: Means of the climatic normal of Abu Sembel meteorological station (2000-2009).

Months	Air temperature (^oC)			Relative humidity (%)	Rain fall (mm)	Evaporation mm	wind speed (km/ h)	Wind direc.
	Max	Min	Aver					
January	23.5	10.1	16.8	43	4	12.0	12.5	N
February	26.1	11.7	18.9	36	5	13.1	13.1	N
March	30.9	15.6	23.4	30	3	16.1	15.2	N.W
April	35.9	20.3	28.1	25	1	19.3	14.7	N
May	39.4	24.2	31.8	21	1	23.9	14.2	N
June	41.6	26.6	34.1	21	0	25.1	15.9	N
July	42.1	27.9	35.0	22	0	24.3	15.4	N
August	43.2	28.4	35.5	23	0	22.7	15.6	N
September	40.1	25.5	32.8	26	0	23.7	15.1	N
October	36.5	22.2	29.4	30	1	19.8	14.1	N
November	30.0	17.5	23.0	38	1	13.4	13.2	N
December	24.9	11.9	18.3	44	8	10.7	12.2	N

Service Source Nation Environmental satellite data and information (NESDIS)

A separate treatment receiving neither N nor S and irrigated with $4Lh^{-1}$ was also conducted as a reference treatment. Thus the total number of treatments is 18 (3irrigation × 3N × 2S) + 1 reference treatment = 19 treatments. Jatropha cuts were cultivated in February 2009 under 2mx2m spacing. Nitrogen was applied in $(NH_4)_2SO_4$ form and S in elemental sulphur. Recommended doses of P and K were applied in the form of ordinary Ca-super phosphate (6.6% P) and potassium sulphate (40% K). Nitrogen was applied in two equal split doses *i.e.,* 1^{st} half in April with full dose of S, P and K and the 2^{nd} half after one month of 1^{st} application. The average values of five plants were considered for analysis.

Determination

- Some physical and chemical analysis of soil at 0-30 and 30-60cm were determined for each treatment after harvesting the crop as described by Klute (1986); Richards (1954) and Jackson (1967).
- Growth characters such as plant height, stem diameter, crown cover and crown volume were determined. Crown cover (m^2) and crown volume (m^3) was calculated by the method described by (Thalen 1979).
- Yield component and yield of jatropha shrubs were determined. The oil was extracted from seeds by using hexane as solvent in soxhlet apparatus Sadasivam and Manickem (1992). Biodiesel yield ($l\ fed^{-1}$) was calculated by

the following formula (Biswas *et al.*, 2010): Biodiesel yield = Seed yield (kg fed^{-1})/ 3.28

Statistical methods:

Data were subjected to statistical analysis according to Gomez and Gomez (1984). Least significance difference L.S.D.at 0.05probability was applied for comparing means.

RESULTS AND DISCUSSION

Effect of irrigation, nitrogen and sulfur levels on some soil physical and chemical properties:

It is clear from Table3 that irrigation at 8 and 12 Lh^{-1} along with adding N and S affected physical and chemical properties of the experiment soil as follows:

Ranges of saturation percent (SP), cation exchange capacity (CEC) and the content of organic matter (OM) were (23.19-29.86% for SP), (2.19-3.24Cmolckg^{-1} for CEC) and (0.14-0.26% for OM) with averages of 27.33%, 2.78 cmolckg^{-1} and 0.20% for SP, CEC and OM, respectively. The highest values are shown by the combination of 30 kg S + 90 kg N under the irrigation rate of 12Lh^{-1} in subsoil (30-60 cm), while the lowest was by the combination of 15 kg S +30 kg N under the irrigation rate of 4Lh^{-1} in the topsoil (0 -30 cm). Also, it was noted that the lowest values under the different studied treatments were higher than of its counterparts in the reference treatment.

In contrast, the lowest values of both temperature and soil pH is shown by the combination of 30kg S + 90kg N under the irrigation rate 12Lh^{-1} in subsoil (30-60 cm), while the highest ones are by the combination of 15kg S + 30kg N under the irrigation rate 4Lh^{-1} in topsoil (0-30 cm). Range of temperature is (26.1-32.0, with an average of 29.5 C^{0}), whereas that for pH is (6.99 -7.65 with an average of 7.24). It was observed that the high values under the different studied treatments were lower than of its counterparts in the reference treatment.

Soil salinity (EC) varied among the treatments. The EC values ranged from 2.36 to 3.10 with an average of 2.69dsm^{-1}. Besides, it was noted that increasing rates of nitrogen and sulfur application increased EC values. Decreasing irrigation rates increased EC values. Generally, the values of EC in the topsoil (0-30 cm) were higher than those in the subsoil (30-60 cm) and the EC of soil receiving N, S and irrigated with 8 and 12Lh^{-1} was lower than those in the reference treatment.

Statistical analysis of the correlation between the studied factors and different soil physical and chemical properties (Table, 4) indicate the followings:

Irrigation had no significant correlation with cation exchange capacity (CEC). However, it had a highly significant positive correlation with saturation percent (SP), electrical conductivity (EC) and organic matter (OM). Besides, Irrigation had a highly significant negative correlation with temperature and a significant negative correlation with each of soil pH.

Table3: Physical and chemical soil properties after treatments at the end of the experiment.

Irrigation rates (Lh^{-1})	Nitrogen	Sulfur	Soil depths in cm	SP %	Temp. C^o	pH	EC dSm^{-1}	CEC cmole kg^{-1}	OM%
	levels in $kgfed^{-1}$					Soil paste extraction			
12	30	15	0-30	27.70	28.0	7.12	2.42	2.19	0.22
			30-60	27.84	28.2	7.09	2.39	2.20	0.21
		30	0-30	28.00	27.9	7.10	2.45	2.24	0.23
			30-60	28.21	27.9	7.04	2.42	2.32	0.22
	60	15	0-30	28.50	28.0	7.09	2.50	2.90	0.24
			30-60	28.63	28.0	7.22	2.44	2.94	0.22
		30	0-30	29.00	26.2	7.11	2.43	3.13	0.26
			30-60	29.25	26.1	7.14	2.36	3.20	0.23
	90	15	0-30	29.30	27.9	7.10	2.60	3.17	0.25
			30-60	29.29	27.2	7.16	2.52	3.21	0.21
		30	0-30	29.00	27.8	6.99	2.76	3.18	0.24
			30-60	29.86	27.7	7.10	2.62	3.24	0.22
8	30	15	0-30	25.70	30.0	7.36	2.56	2.30	0.18
			30-60	25.81	30.0	7.44	2.46	2.35	0.16
		30	0-30	26.00	29.5	7.23	2.71	2.68	0.19
			30-60	25.89	29.4	7.45	2.67	2.70	0.17
	60	15	0-30	27.00	29.7	7.16	2.86	2.64	0.18
			30-60	26.92	29.7	7.35	2.79	2.69	0.17
		30	0-30	27.10	29.9	7.25	2.42	2.62	0.18
			30-60	27.89	29.8	7.11	2.41	2.71	0.20
	90	15	0-30	27.70	30.0	7.20	2.71	3.11	0.22
			30-60	28.10	30.0	7.09	2.64	3.17	0.23
		30	0-30	27.90	29.5	7.00	2.86	3.10	0.22
			30-60	28.14	29.5	7.15	2.79	3.21	0.21
4	30	15	0-30	23.19	32.0	7.62	2.86	2.33	0.16
			30-60	24.00	31.8	7.65	2.85	2.37	0.14
		30	0-30	25.30	30.8	7.46	2.95	2.61	0.17
			30-60	25.74	30.6	7.51	2.86	2.67	0.16
	60	15	0-30	26.70	31.5	7.36	2.96	2.50	0.18
			30-60	25.98	31.4	7.41	2.97	2.49	0.16
		30	0-30	27.12	31.0	7.28	2.91	2.93	0.17
			30-60	27.57	29.7	7.31	2.89	2.92	0.16
	90	15	0-30	27.30	31.3	7.27	2.95	2.95	0.18
			30-60	27.79	30.9	7.29	2.87	2.90	0.18
		30	0-30	27.11	31.3	7.12	2.96	3.02	0.18
			30-60	27.42	31.1	7.19	2.95	3.10	0.18
Reference treatment			0-30	23.05	32.9	7.84	3.10	2.01	0.13
			30-60	23.14	32.4	7.86	2.97	2.03	0.12

Table4: Correlation between the studied treatments and different soil physical and chemical properties

Treatments	Saturation percent	Temperature	pH	EC	CEC	OM
Irrigation	0.71**	-0.92**	-0.67*	0.85**	ns	0.83**
Nitrogen	0.71**	ns	-0.66*	ns	0.85**	0.49*
Sulfur	0.56*	-0.48*	-0.64*	-0.31*	0.55*	0.47*

ns = not significant

Nitrogen had no significant correlation with both temperature and EC. However, it had a highly significant positive correlation with SP and CEC and only significant positive correlation with OM. It had significant negative correlation with pH.

Sulfur had significant positive correlation with each of SP, CEC and OM, while it had significant negative correlation with temperature, pH and EC. These results are in agreement with those obtained by Draz and El-Maghraby (1997) and Zaghloul (2006).

Effect of irrigation, nitrogen and sulfur on the vegetative growth characteristics and yield values:

As general data in Table 5 show that there were differences between the effects of the different treatments of irrigation, nitrogen and sulfur on the vegetative growth parameters, (plant height, stem diameter, crown volume and crown cover) and on yield (the fruit yield/tree, fruit yield/fed, seed yield/tree, seed yield/fed, biodiesel yield/fed, oil yield/fed, oil content and protein content in seeds) as follows:

i - Effect of irrigation treatments on vegetative growth and yield values:

a - Effect of irrigation treatments on vegetative growth characteristics:

There were significant differences between the different irrigation treatments and the highest values for vegetative growth characteristics were for the 2 and 8 Lh^{-1} irrigation treatment and the lowest value was for the 4 Lh^{-1} treatment.

There was a significant increase in the volume and cover crown with at the 12 Lh^{-1} treatment as compared with 8 Lh^{-1} one. There were no significant differences between the same two levels on each of the plant height and the stem diameter in the first year. The same trend occurred in the second year with the exception that there was no significant difference between the 12 and 8 Lh^{-1} treatments on the diameter of the crown. These results are in agreement with Mazher *et al.* (2010) and Patolia *et al*. (2007).

b- Effect of irrigation on yield characteristics:

As shown in Table 6, it is clear that there are significant differences between irrigation treatments on the yields of jatropha, while there were no significant differences between the 12 Lh-1 and 8 Lh-1, except that there are significant increase for oil % at the level of 12 Lh-1 compared with the 8 Lh^{-1} treatment. A similar trend occurred in the second year. These results are similar to those of Yin *et al*. (2010).

ii - Effect of Nitrogen on vegetative growth and yields:

a - Effect of nitrogen on vegetative growth characteristics:

Generally, values of vegetative growth characteristics were higher under the effect of the different treatments of nitrogen application compared to the reference treatment. Growth values increased with the increase in nitrogen application. By increasing the levels of N application from 30 kg to 90 $kgfed^{-1}$ vegetative growth characteristics increased by 28, 23, 119 and 67% for plant height, stem diameter, crown volume and crown cover, respectively in the 1st year. Similar trend occurred in the 2nd year.

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b - Effect of nitrogen on yields:

Yield values increased with increasing the level of nitrogen application. The highest values were obtained at the level of 90 kg Nfed^{-1} which gave 5.42 kg fruits tree^{-1}, 5.69 Mg fruits fed^{-1}, 0.55 kg seeds tree^{-1}, 0.900 Mg seeds fed^{-1}, 274.5 l diesel fed^{-1} and 335 liter oil fed^{-1} in the 1st year. It was noted the same trend was attained in the 2nd year. These results are in accordance with those of Haneklaus *et al*. (1999) and Malhi *et al*. (2007).

iii - Effect of sulfur on vegetative growth and yields:

a - Effect of sulfur on vegetative growth characteristics:

The increase in the level of sulfur application resulted in significant increase in the vegetative growth characteristics**.** The highest values occurred at the level of 30kgSfed^{-1} which gave the followings in the 1st year: 1.91 m, 0.30 m, 0.35 m^3, 2.16 m^2 for plant height, stem diameter, crown volume and crown cover, respectively. The same trend was observed in the 2nd year, except that there was no significant difference between levels 15 and 30 kg fed^{-1} on the stem diameter (0.31 m) but it was greater than that in the reference treatment (0.20m). The same trend was noted in the 2nd year.

b- Effect of sulfur on the yields:

In both years, it was observed that the increase in the rates of sulfur led to a significant increase in the different yield of values, but there were no significant differences between levels 15 and 30 kg fed^{-1} on the seed protein content. These results are in accordance with those obtained by Fismes *et al*. (2000).

iv - The effect of interaction between the of irrigation, nitrogen and sulfur on the vegetative growth characteristics and yields:

As shown in Tables 6 & 7, in general, it is clear that there were significant differences in the effect of interaction between irrigation, nitrogen and sulfur on vegetative growth and yield characteristics as follows:

a. Effect of interaction between irrigation, nitrogen and sulfur on vegetative growth characteristics:

As shown in Table 6, it is clear that there are significant differences between the treatments of the studied factors on the vegetative growth characteristics. The highest values were found at 30 kg S fed^{-1} under 90 kg N fed^{-1} under the 12 Lh^{-1} irrigation, where it was 2.19 m, 0.37 m, 0.57 m^3 and 2.98 m^2 for plant height, stem diameter, crown volume and crown cover, respectively. It was also noted that no significant differences between the effect of the 12 and 8 Lh^{-1} irrigations either at 15or 30 kgSfed^{-1} under the 90 kg N fed^{-1} on plant height and crown cover. On the other hand, the lowest values were observed at 15 kg S fed^{-1} under the level of 30 kg N fed^{-1} under the irrigation rate of 4Lh^{-1}. Similar trend was noticed in the 2nd year, except that, there were significant differences between the effect of the 12 and 8 Lh^{-1} rates either at 15 or 30 kg S fed^{-1} under 90kgNfed^{-1}.

It was also noticed that no significant differences between the 12 and 8 Lh^{-1} irrigations at 15 or 30 kgSfed^{-1} under 90 kg N fed^{-1} either on plant height or crown cover. On the other hand had, the lowest values were observed at 15 kg S fed^{-1} under 30 kg N fed^{-1} and the 4Lh^{-1}irrigation in the 1st year. Same trend was observed in the 2nd year except that there were significant differences between the 12 and 8 Lh^{-1} irrigation at 15 or 30 kg S fed^{-1} under the 90 kg N fed^{-1}. On the other hand, the lowest values were observed with 15 kg S fed^{-1} under 30kg N fed^{-1} and 4Lh^{-1}. The same trend was observed in the second year.

Table6: Effect of interaction between irrigation, nitrogen and sulfur rates on growth parameters of *Jatropha curcus* shrubs.

Irrigation levels (Lh^{-1})	Nitrogen Levels In $kgfed^{-1}$	Sulfur levels in $kgfed^{-1}$	Plant height in m	Stem diameter in m	Crown volume in m^3	Crown Cover in m^2	Plant height in m	Stem diameter in m	Crown volume in m_3	Crown Cover in m^2
			1st Year				2nd Year			
12	30	15	1.58	0.27	0.22	1.52	1.68	0.29	0.24	1.59
		30	1.73	0.28	0.27	1.85	1.79	0.31	0.31	1.88
	60	15	1.9	0.29	0.34	2.26	1.91	0.32	0.36	2.15
		30	2.00	0.31	0.42	2.58	2.10	0.33	0.44	2.53
	90	15	2.13	0.34	0.48	2.73	2.40	0.36	0.58	3.10
		30	2.19	0.37	0.57	2.98	2.70	0.39	0.74	3.64
8	30	15	1.55	0.26	0.19	1.41	1.58	0.28	0.22	1.53
		30	1.72	0.27	0.24	1.68	1.79	0.29	0.29	1.90
	60	15	1.97	0.30	0.30	1.91	1.82	0.33	0.35	2.03
		30	2.05	0.31	0.38	2.33	1.92	0.34	0.39	2.18
	90	15	2.10	0.32	0.41	2.50	2.11	0.35	0.46	2.51
		30	2.17	0.33	0.45	2.60	2.17	0.36	0.54	2.87
4	30	15	1.38	0.21	0.13	1.12	1.45	0.24	0.14	1.10
		30	1.63	0.26	0.19	1.39	1.62	0.27	0.21	1.49
	60	15	1.77	0.27	0.23	1.64	1.68	0.28	0.26	1.75
		30	1.83	0.27	0.27	1.90	1.77	0.30	0.31	1.98
	90	15	1.90	0.29	0.31	2.01	1.82	0.31	0.35	2.13
		30	1.97	0.3	0.34	2.13	1.93	0.31	0.38	2.33
$LSD_{at0.05}$			0.11	0.02	0.05	0.28	0.29	0.02	0.07	0.43
Reference treatment			1.35	0.19	0.11	1.1	1.4	0.2	0.11	1.09

b. Effect of interaction between the treatments of irrigation, nitrogen and sulfur on the yields:

As shown in Table 7, it is clear that there are significant differences between the treatments of the studied various factors on the yield characteristics, where the highest values were noticed at the 30 kg S fed^{-1} under the 90 kg N fed^{-1} under 8 Lh^{-1} irrigation (i.e. 6.19 kg fruits $tree^{-1}$, 6.50 Mg fruits fed^{-1}, 0.962 kg seeds $tree^{-1}$, 1.010 Mg seeds fed^{-1}, 307.9 l biodiesel fed^{-1}, 381.5 kg oil fed^{-1}.

There were no significant differences between the treatments of 30 kg S fed^{-1} under the 90 kg N fed^{-1} either under 12 or 8 Lh^{-1} irrigation for the same characteristics. As for the characteristics of seed oil and protein content, the highest values was only recorded at the level of 30 kg S fed^{-1} under the level of 90 kg N fed^{-1} under the irrigation rate of 12 Lh^{-1}, which was 39.85% for oil, 24.55% of protein. These results are in agreement with Yin *et al.* (2010) and Suriharn *et al*. (2011).

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Effect of irrigation, nitrogen and sulfur treatments on seeds macronutrients (NPK) uptake:

As shown in the Table 8, it is clear that in both years there were positive significant differences between the levels of irrigation, nitrogen and sulfur on seeds uptake of N, P and K.

Table8: Effect of irrigation, nitrogen and sulfur rates on macronutrients (NPK) uptake *by Jatropha curcus* seeds.

Factors	Levels	1st year			2nd year		
		N	P	K	N	P	K
		Uptake in $mgkg^{-1}$ seeds					
Irrigation Lh^{-1}	12	26.50	13.19	11.39	26.49	13.32	11.34
	8	25.36	12.45	10.87	25.34	12.56	10.78
	4	22.68	10.66	9.52	22.68	11.12	9.52
$LSD_{at\ 0.05}$		0.78	0.38	0.33	0.78	0.38	0.33
Nitrogen $kgfed^{-1}$	30	22.73	11.50	9.78	22.69	11.70	9.70
	60	24.92	11.80	10.70	24.93	12.29	10.63
	90	26.87	13.00	11.31	26.89	13.02	11.31
$LSD_{at\ 0.05}$		0.78	0.38	0.33	0.78	0.38	0.33
Sulfur $kgfed^{-1}$	15	24.41	11.87	10.40	24.42	11.92	10.31
	30	25.28	12.33	10.79	25.26	12.45	10.78
$LSD_{at\ 0.05}$		0.64	0.31	0.27	0.63	0.31	0.27
Reference treatment		17.58	8.41	7.44	17.19	8.23	7.20

In general, all values under the different used levels were higher than those of the reference treatment.

a. Irrigation effect:

The highest values of uptake of nutrients by seeds were resulted by the $12Lh^{-1}$ treatment, while the lowest ones were obtained by the $4Lh^{-1}$ treatment. The increases were 16.8, 23.7 and 19% for N, P and K, respectively, in the 1st year for $12Lh^{-1}$ treatment compared with the $4Lh^{-1}$ treatment. The same trend occurred in the 2nd year.

b. Nitrogen effect:

Data shown in Table 8 indicate that increasing rates of added nitrogen from 30 to 90 kg fed^{-1} resulted in an increase in seeds macronutrients uptake, and this increase represents 18.2, 13.0 and 15.6% for each of N, P and K, respectively, at the level of 90kg $Nfed^{-1}$ compared with 30kg $Nfed^{-1}$ in the 1st year. Similar trend occurred in the 2nd year.

c. Sulfur effect:

Table 8 shows that, raised sulfur level from 15 to 30kg fed^{-1} increased the uptake of N, P and K in seeds, where they represented about 3.6, 3.9, 3.7% for N, P and S, respectively, at the 30kg S fed^{-1} compared with the 15kg $Sfed^{-1}$ in the 1st year, but this increase was lower than those resulting increase at the highest rate of irrigation and the highest level of nitrogen. The same trend occurred in the 2nd year.

d. Effect of interaction between the treatments of irrigation, nitrogen and sulfur on seeds macronutrients (NPK) uptake:

As shown in Table 9 it is clear that there were significant differences between the different levels for each of the irrigation, nitrogen and sulfur on the seeds macronutrients uptake.

The highest values were present at the 30kg S fed^{-1} under the 90kg N fed^{-1} under the 12Lh^{-1} irrigation, where these values, in the 1st year, were 28.75, 13.97, and 12.18 mgkg^{-1} seeds for each of N, P and K, respectively. These values did not differ significantly from the same levels of nitrogen and sulfur under the 8Lh^{-1}irrigation. On the other hand, the lowest uptake values by seeds occurred with 15kgSfed^{-1} under the level 30 kg N fed^{-1} under 4Lh^{-1} irrigation. The same trend occurred in the 2nd year.

The greatest benefit from fertilizer application can be derived under irrigated conditions, where water supply is least likely to limit nutrient uptake. With adequate nutrient supply, plants that are limited in growth due to moisture stress would have a higher percent of mineral nutrients than plants under comparable fertility but not limited in growth by moisture supply (Michael, 1981).

Table9: Effect of interaction among irrigation, nitrogen and sulfur rates on macronutrients uptake in seeds *Jatropha curcus* shrubs.

Irrigation levels (Lh^{-1})	Nitrogen levels kgfed^{-1}	Sulfur Levels kgfed^{-1}	1st year			2nd year		
			N	P	K	N	P	K
			Uptake in mg kg^{-1} seeds					
12	30	15	24.39	12.39	10.62	24.34	13.09	10.39
		30	25.31	13.01	10.99	25.33	12.94	11.01
	60	15	26.00	12.94	11.34	26.01	12.98	11.21
		30	26.75	13.32	11.51	26.75	13.32	11.58
	90	15	27.85	13.50	11.72	27.90	13.65	11.71
		30	28.75	13.97	12.18	28.58	13.96	12.15
8	30	15	22.41	11.30	9.69	22.39	11.78	9.51
		30	23.27	11.62	9.94	23.13	11.62	9.93
	60	15	24.70	12.04	10.74	24.66	12.18	10.36
		30	26.33	12.87	11.29	26.35	12.88	11.38
	90	15	27.83	13.30	11.64	27.87	13.36	11.61
		30	27.99	13.55	11.93	27.93	13.53	11.87
4	30	15	20.26	10.19	8.54	20.24	10.31	8.50
		30	20.76	10.47	8.92	20.73	10.44	8.84
	60	15	22.33	9.51	9.26	22.29	10.92	9.33
		30	23.43	10.12	10.05	23.51	11.44	9.91
	90	15	24.34	11.65	10.07	24.34	11.67	10.21
		30	24.94	12.02	10.29	24.99	11.94	10.32
$LSD_{at0.05}$			0.93	0.81	0.88	0.94	0.80	0.61
Reference treatment			17.58	8.41	7.44	17.19	8.23	7.20

CONCLUSION

The results indicate that jatropha shrubs treated with different irrigation rates, and fertilized with nitrogen and sulfur play an important role of improving of physical and chemical soil properties. Increasing irrigation rates and levels of N and S resulted in significant increase in vegetative growth and yield characteristics. Also, seed oil content, diesel content and NPK uptake were increased. there was no significant difference between the rate of 12 and $8Lh^{-1}$ on most of vegetative growth and yield characteristics. The highest values of vegetative growth and yield characteristics were found at the level of 30kg $Sfed^{-1}$ under the level of 90kg $Nfed^{-1}$ under the irrigation rate of $12Lh^{-1}$.

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تـأثير بعض المعـاملات الزراعيـة علـى نبـات الجاتروفـا المنـزرع فـى تربـة منقولـة بالـهواء فى توشكى ، الصحراء الغربية ، مصر

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أجريت تجربتين خلال عامين متتاليين (2010 ، 2011) بهدف دراسة تأثير بعض المعاملات الزراعية على شجيرة الجاتروفا المنزرعة تحت ظروف الرواسب الهوائية بمحطة بحوث توشكى (مركز بحوث الصحراء) بأسوان. وقد صممت التجربة فى قطاعات كاملة العشوائية بنظام القطع المنشقة مرتين. وكانت العوامل المدروسة هى ثلاث معدلات من كل من الرى (عامل رئيسى) (12 ، 8 ، 4 لتر/ساعة) والنيتروجين (عامل تحت رئيسى) (30 ، 60 ، 90كجم/فدان) ومعدلين من الكبريت (عامل تحت تحت رئيسى) (15 ، 30كجم/فدان) ، وكل معاملة كررت ثلاث مرات مع وجود معاملة المقارنة (صفر نيتروجين وصفر كبريت تحت معدل رى 4لتر/ساعة).

وقد قدرت بعض الصفات الطبيعية والكيميائية للتربة والتى تشمل الرطوبة (السعة الحقلية) ، الحرارة ، والحموضة ، والملوحة ، والسعة التبادلية الكاتيونية ، % للمادة العضوية ، وعناصر النيتروجين والفوسفور والبوتاسيوم الميسر). كما قدرت صفات النمو الخضرية (إرتفاع النبات – قطر الساق – غطاء التاج – حجم التاج) والصفات الإنتاجية مثل (إنتاجية الثمار/شجرة – إنتاجية الثمار/فدان - إنتاجية البذور/شجرة – إنتاجية البذور/فدان – إنتاجية الزيت كجم/فدان – إنتاجية البيوديزل لتر/فدان). وأيضاً قدر محتوى البذور من كل من الزيت والبروتين والممتص من العناصر الكبرى (NPK) .

وقد دلت النتائج على أن شجيرات الجاتروفا المعاملة بمعدلات مختلفة من الرى والنيتروجين والكبريت لعبت دوراً مهماً فى تحسين بعض الصفات الطبيعية والكيميائية للتربة. وكانت هناك زيادة معنوية بزيادة معدلات الرى والنيتروجين والكبريت فى كل من الصفات الخضرية والإنتاجية ومحتوى البذور من كل من الزيت والبروتين والممتص من عناصر النيتروجين والفوسفور والبوتاسيوم. كما أنه من المهم أن نوضح أنه لم يلاحظ وجود فروق معنوية فى تأثير معدلين الرى (12 ، 8لتر/ساعة) فى معظم الصفات الخضرية والإنتاجية لشجيرات الجاتروفا. وبصفة عامة وجدت أعلى القيم لصفات النمو الخضرية والإنتاجية لشجيرات الجاتروفا عند معدل الإضافة 30كجم من الكبريت تحت المستوى 90كجم من النيتروجين عند معدل الرى 12لتر/ساعة.

قام بتحكيم البحث

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Table5:Main effects of irrigation, nitrogen and sulfur treatments on vegetative growth and yields of *Jatropha curcus* shrubs.

Growth and Yield Parameters		Irrigation Lh^{-1}			LSD at 0.05	Nitrogen levels $kgfed^{-1}$			LSD at 0.05	Sulfur levels $kgfed^{-1}$		LSD at 0.05	Referen. treatment
		12	8	4		30	60	90		15	30		
		1st year											
Growth	Height in m	1.89	1.93	1.71	0.05	1.60	1.91	2.04	0.05	1.80	1.91	0.04	1.35
	Stem diameter in m	0.31	0.30	0.27	0.01	0.26	0.29	0.32	0.01	0.28	0.30	0.01	0.19
	Crown volume in m^3	0.38	0.33	0.25	0.02	0.20	0.32	0.43	0.02	0.29	0.35	0.02	0.11
	Crown Cover in m^2	2.32	2.07	1.70	0.11	1.49	2.10	2.49	0.11	1.90	2.16	0.09	1.10
Yield	Fruit yield $shrub^{-1}$ in kg	4.75	4.93	3.61	0.23	3.42	4.45	5.42	0.23	4.18	4.68	0.19	1.737
	Fruit yield fed^{-1} in Mg	4.99	5.18	3.80	0.24	3.60	4.67	5.69	0.24	4.39	4.91	0.20	1.824
	Seed yield $shrub^{-1}$ in kg	0.806	0.828	0.651	0.044	0.662	0.765	0.858	0.044	0.738	0.786	0.036	0.426
	Seed yield fed^{-1} in Mg	0.847	0.869	0.684	0.046	0.695	0.804	0.900	0.046	0.755	0.825	0.037	0.447
	Biodiesel yield in L fed^{-1}	258.1	265.0	208.4	13.96	212.0	245.0	274.5	13.96	236.1	251.5	11.40	136.4
	Oil yield in L fed^{-1}	322.5	321.7	244.1	16.87	257.5	295.8	335.0	16.87	280.5	311.7	13.77	148.1
	Oil seed %	38.09	37.01	35.60	0.29	36.38	36.73	37.14	0.29	36.10	37.70	0.23	33.11
	Protein seed %	24.22	24.23	24.19	0.05	24.07	24.13	24.43	0.05	24.19	24.23	0.04	23.07
		2nd year											
Growth	Height in m	2.10	1.99	1.75	0.12	1.65	1.92	2.19	0.12	1.83	1.98	0.10	1.40
	Stem diameter in m	0.33	0.33	0.29	0.01	0.28	0.32	0.35	0.01	0.31	0.31	0.01	0.20
	Crown volume in m	0.43	0.38	0.27	0.03	0.23	0.35	0.51	0.03	0.32	0.38	0.02	0.11
	Crown Cover in m^2	2.48	2.17	1.80	0.17	1.58	2.10	2.76	0.17	1.99	2.31	0.14	1.09
Yield	Fruit yield $shrub^{-1}$ in kg	5.91	5.80	3.78	0.44	3.87	5.16	5.47	0.44	4.87	5.45	0.36	1.996
	Fruit yield fed^{-1} in Mg	6.20	6.09	3.97	0.47	4.06	5.42	6.79	0.47	5.12	5.72	0.38	2.096
	Seed yield $shrub^{-1}$ in kg	0.988	0.938	0.718	0.064	0.700	0.932	1.012	0.064	0.849	0.914	0.053	0.457
	Seed yield fed^{-1} in Mg	1.037	0.985	0.754	0.068	0.735	0.978	1.063	0.068	0.891	0.959	0.055	0.480
	Biodiesel yield in L fed^{-1}	316.2	300.4	229.8	20.57	224.2	298.2	324.0	20.57	271.7	292.5	16.79	146.2
	Oil yield in L fed^{-1}	397.7	372.9	273.5	26.10	268.5	368.0	407.6	26.10	332.2	364.0	21.31	163.5
	Oil seed %	38.23	37.72	36.18	0.14	36.41	37.48	38.24	0.14	37.01	37.74	0.12	34.09
	Protein seed %	24.21	24.21	24.19	0.02	24.03	24.14	24.44	0.02	24.20	24.21	0.01	23.04

Table7: Effect of irrigation, nitrogen and sulfur rates on vegetative growth characteristics and yields of *Jatropha curcus* shrubs.

Irrigation levels (Lh^{-1})	Nitrogen levels $kgfed^{-1}$	Sulfur Levels $kgfed^{-1}$	Fruit yield $shrub^{-1}$ in kg	Fruit yield fed^{-1} in Mg	Seed yield $shrub^{-1}$ in kg	Seed yield fed^{-1} in Mg	Oil %	Protein %	Biodiesel yield in L fed^{-1}	Oil yield in L fed^{-1}	Fruit yield $shrub^{-1}$ in kg	Fruit yield fed^{-1} in Mg	Seed yield $shrub^{-1}$ in kg	Seed yield fed^{-1} in Mg	Oil %	Protein %	Biodiesel yield in L fed^{-1}	Oil yield in L fed^{-1}
			1st Year								2nd Year							
12	30	15	3.54	3.71	0.684	0.719	37.77	24.05	219.1	271.4	4.49	4.72	0.769	0.808	36.52	23.99	246.3	295.0
		30	3.98	4.18	0.741	0.778	38.24	24.02	237.3	308	4.76	5.00	0.801	0.841	37.84	24.04	256.3	318.1
	60	15	4.36	4.58	0.772	0.811	36.83	24.11	247.2	298.6	5.25	5.51	1.033	1.085	38.06	24.12	330.8	413.0
		30	4.98	5.23	0.835	0.876	38.32	24.12	267.2	335.9	6.17	6.48	1.091	1.146	38.48	24.12	349.3	440.9
	90	15	5.45	5.73	0.861	0.904	37.79	24.45	275.5	341.5	7.11	7.47	1.099	1.154	38.65	24.42	351.8	446.0
		30	6.18	6.49	0.945	0.993	39.58	24.55	302.6	379.6	7.66	8.04	1.132	1.189	39.83	24.56	362.4	473.5
8	30	15	3.65	3.83	0.694	0.729	36.58	24.01	222.1	266.5	4.17	4.38	0.707	0.742	35.93	23.99	226.2	266.6
		30	4.00	4.20	0.730	0.767	38.12	24.32	233.8	292.4	4.87	5.11	0.752	0.790	37.33	24.17	240.8	294.8
	60	15	4.51	4.74	0.793	0.832	35.6	24.17	253.8	296.3	5.31	5.58	0.956	1.004	37.73	24.13	306.0	378.6
		30	5.39	5.66	0.859	0.902	37.82	24.14	274.9	341	6.28	6.59	1.102	1.157	37.9	24.16	352.8	438.5
	90	15	5.83	6.12	0.929	0.975	36.17	24.32	297.3	352.7	6.84	7.19	1.049	1.102	38.53	24.43	335.9	424.6
		30	6.19	6.50	0.962	1.010	37.78	24.41	307.9	381.5	7.34	7.71	1.064	1.117	38.88	24.37	340.7	434.5
4	30	15	2.45	2.57	0.550	0.578	33.29	23.99	176.2	192.4	2.08	2.19	0.533	0.559	34.90	23.96	170.5	195.2
		30	2.93	3.08	0.572	0.601	35.64	24.07	183.2	214.1	2.82	2.96	0.640	0.672	35.91	24.03	204.9	241.4
	60	15	3.63	3.82	0.646	0.679	34.98	24.17	207	237.4	3.82	4.01	0.679	0.713	36.18	24.13	217.3	257.9
		30	3.82	4.01	0.688	0.722	36.81	24.08	220.2	265.8	4.12	4.32	0.729	0.765	36.53	24.16	233.2	279.4
	90	15	4.21	4.42	0.71	0.745	35.89	24.47	227.2	267.5	4.79	5.03	0.815	0.855	36.54	24.47	260.8	312.6
		30	4.64	4.87	0.739	0.776	36.97	24.36	236.7	287.1	5.05	5.30	0.913	0.959	37.00	24.40	292.3	354.7
$LSD_{at0.05}$			0.56	0.59	0.110	0.110	0.70	0.12	34.2	41.3	1.09	1.14	0.160	0.17	0.35	0.04	50.4	63.9
Reference treatment			1.737	1.824	0.426	0.447	33.11	23.07	136.4	148.1	1.996	2.096	0.457	0.48	34.09	23.04	146.2	163.5