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Effect of Irrigation Intervals and Nitrogen Sources on Growth and Mineral Status of Jatropha Plants

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ABSTRACT

In a pot experiment in the greenhouse of the National Research Centre, a study aimed to evaluate the influences of nitrogen sources and irrigation by diluted seawater on growth and some chemical constituents of jatropha plants. The irrigation interval treatments were: 4, 8 and 12 days. The Nitrogen sources used were; ammonium nitrate (AN-33.5% N), ammonium sulfate (AS-20.5 % N), urea (U - 46.5 %N) and calcium nitrate (Ca-N-15.5% N) added in the rate of 60 kg/fed in two equal portions. The plant height, root length, number of green leaves and fresh and dry weight of different plant parts as well as the whole plant fresh and dry weight values seemed to be equals under different irrigation intervals. This means that the irrigation every 12 days or less did not affected significantly the all growth traits under study. The longest plants and have more green leaves were produced by application of nitrogen fertilizer as ammonium nitrate. This was true for stem, leaves and whole plant fresh as well as dry weight. On reverse, the lesser effects of different nitrogen sources were observed by calcium nitrate. This was hold fairly true for different growth parameters. Widening of irrigation intervals showed a positive effect on N, P and K concentrations. The reverse was true for Mn and Cu concentration. Meanwhile, Fe and Zn concentration increase by the 1st irrigation widening and tended to decrease with the 2nd treatment of irrigation interval to be less than the control. Ca concentration was reversely responded. Furthermore, Na concentration was increased only by the more wide interval used. Irrigation jatropha plants every 8 days increased P, Fe and Cu but used 12 days interval decreased its uptake. The opposite response for K and Ca uptake was observed. However, N and Zn uptake improved by both drought treatments. The highest values of N and Ca concentrations were obtained by application of ammonium sulfate, however, for P, Mn and Cu concentrations high values were observed by ammonium nitrate treatment. Ammonium sulfate showed the highest percentages of N, K, Ca, Na, Zn and Cu while ammonium nitrate gave the highest uptake of P and Mn but for Fe uptake it was obtained in control plants. On reverse, the lowest uptake of N, P, K, Ca, Na, Mn and Cu were by application of calcium nitrate, however, for Fe uptake it was by addition of ammonium sulfate.

Key words: Jatropha-Irrigation intervals-Nitrogen fertilizer sources-Growth dry- matter- Mineral uptake.

Introduction

Jatropha curcus is a drought-resistant perennial, growing well in marginal/poor soil. It is easy to establish, grows relatively quickly and lives, producing seeds for 50 years. Jatropha the wonder plant produces seeds with an oil content of 37%. The oil can be combusted as fuel without being refined. It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine. The by-products are press cake a good organic fertilizer and oil contains also insecticide. One of the reasons for this is that Jatropha trees grown by 'natural' generative plant propagation (from seeds) have unique root architecture, comprising a thick central taproot and four laterals. According to Reinhard Henning of Bagani, a Germany based organization: with this central taproot a tree can extract minerals from deep inside the soil like a "minerals pump", which promotes soil fertilization recovery and faster plant growth. Secondly, when the taproot is simultaneously able to withdraw water from deeper soil layers this contributes to the tree's drought resistance and a further increase in overall plant growth and seed production.' In addition, the four lateral roots as a distinct Jatropha plant feature provide additional structure to the surrounding soil, which gives a positive contribution to the soil water storage capacity and soil erosion control. Several researchers concluded that jatropha thrived as a drought resistant plant (Vries, 2007 and Kharia and Atta, 2009 and Silva, *et al.* 2010).

However, Vries (2007) considered that jatropha a drought resistant tree but showed that its relative drought resistant tree. Also, In spite of this tree resistant to drought but the water deficit affected their growth and yield (Saei, et al. 2006; Alva, *et al.* 2008; Kharia and Atta, 2009 and Reddy and Match, 2010).

Nitrogen application and its sources affected the growth of trees considerably as shown by: Shen, *et al*. (1993); and Fernández-Escobar, *et al.* (2009).

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Moreover, the application of nitrogen fertilizer from different sources resulted in different growth parameter responses of trees under different irrigation regimes (Hussein, 2008 and Toplu, *et al*. 2009). Addition of nitrogen fertilizer lowered the adverse effect of drought on growth of plants: Toplu, *et al.* (2009)

Therefore, this work performed to investigate the effect of different sources of nitrogen under different irrigation intervals on growth of jatropha plants in the early stages of growth.

Material and Methods

In a pot experiment in the greenhouse of the National Research Centre, a study aimed to evaluate the influences of nitrogen sources and irrigation by diluted seawater on growth and some chemical constituents of jatropha plants. The treatments were as follows:

Drought Irrigation intervals: 4, 7 and 12 days between irrigations.

Nitrogen sources, Ammonium sulphate (AS), Ammonium nitrate(AN), Calcium nitrate(Ca-N), Urea(U) and the control without mineral fertilizer.

The experiment included 15 treatments which were the combination of three treatments of irrigation by 5 fertilization treatments i.e. ammonium nitrate, ammonium sulphate, calcium nitrate, and urea , control plants without mineral fertilizer. The experimental design was split plot in 8 replicates. Metallic ten pots 35 cm. in diameter and 50 cm. in depth were used. Every pot contained 30 Kg. of air dried clay loam soil. The inner surface of the pots was coated with three layers of bitumen to prevent direct contact between the soil and metal; in this system, 2 kg of gravel (Particles about 2-3 cm in diameter), so the movement of water from the base upward.

Seeds of jatropha (*Jatropha curcus L.*) were sown at May, 20 and seedlings were thinned left three plants / pot. Calcium super phosphate (15.5 % $P_2 0_5$) and potassium sulfate (48.5 % $k_2 0$) in the rate of 3.0 and 1.50 g/pot were added before sowing. Nitrogen fertilizers were added as a treatments pot was added in two equal portions, the first at 21 days from sowing and the second two weeks latter. Irrigation treatments were started 21 days from sowing.

Samples from every sub treatment were collected, cleaned, and dried in electric furnace at 70 ºC until fixed weight. The dried samples were grown in a stainless steel mill. The digestion and determination of macro and micro nutrients were done according to the methods described by Cottinee, *et al*. (1982).

All collected Data were subjected to the proper statistical analysis according to Snedecor and Cochran (1982).

Table 1: Analytical data of the experimental soil.

A . Soil mechanical analysis

Sand		Silt	Clay	Soil Texture
Course >200 µ %	Fine 200-20µ %	20-2 µ %	< 2 µ %	
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 meq/100 g soil							
					Na^+	K^+	Ca^{2+}	Mg^{2+}	CO^{-3}	HCO^{-3}	Cl^{-1}	SO^{-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

Result and Desiccation

❖ *Growth:*

Irrigation:

As shown in Table (2) the plant height, root length, number of green leaves and fresh and dry weight of different plant parts as well as the whole plant fresh and dry weight values seemed to be equals under different irrigation intervals. This means that the irrigation every 12 days or less did not affected significantly the all growth traits under study.

Table 2: Effect of irrigation stress on growth of jatropha plants.

Irrigation Intervals Days	Plant height (cm)	Root length (cm)	Leaves number	Leaves area (cm)	Fresh weight (g)				Dry weight (g)			
					Root	Stem	Leaves	Total	Root	Stem	Leaves	Total
4	94.26	20.58	56.2	6399	53.5	195.4	172.5	421.4	11.45	40.22	37.14	88.81
8	97.28	19.68	54.5	6166	48.4	177.4	146.8	372.6	11.28	36.82	33.97	82.07
12	95.40	19.46	54.6	6042	43.7	165.8	151.2	360.7	10.37	33.21	38.53	82.11
LSD at 5%	N.S	N.S	N.S	298	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Water availability is thought to be the most critical limiting factor for photosynthesis, and hence for agriculture. A lack of water has deleterious effects on numerous plant processes which can impinge on photosynthesis with productivity reduction; however, the reverse is true for plants best supplied with water (Sakr and Gaballa, 2009). Hu, *et al*. (2007) found that drought and salinity reduced the fresh weight content regardless of leaf number and caused a similar reduction. However, they affected the dry weight content differently, resulting from the reduction in the relative water content by drought. Vries (2007) mentioned that another potential advantage of cultivating Jatropha, more than it is a good source of oil, is its relative drought resistance - it has a minimum requirement of 300 mm rainfall per annum to survive, and 600 mm needed to bear fruits. Kheira and Attia (2009) noticed that Jatropha can survive and produce full yield with high quality seeds under minimum water requirements compared to other crops.

Nitrogen sources:

Data presented in Table (3) indicated that longest plants and have greener leaves were produced by application of nitrogen fertilizer as ammonium nitrate. These were true for stem, leaves and whole plant fresh as well as dry weight. On reverse, the lesser effects of different nitrogen sources were observed by calcium nitrate. This was hold fairly true for different growth parameters.

Table 3: Effect of nitrogen sources on growth of jatropha plants.

Nitrogen of sources	Plant height (cm)	Root length (cm)	Leaves number	Leaves area (cm)	Fresh weight (g)				Dry weight (g)			
					Root	Stem	Leaves	Total	Root	Stem	Leaves	Total
Control	81.8	19.98	44.3	6355	47.70	168.4	129.1	342.2	13.23	35.63	36.28	85.14
AN	106.8	20.63	62.7	6513	49.97	217.5	180.1	447.5	10.98	45.35	41.76	98.09
AS	96.8	22.77	59.1	7250	50.33	185.5	163.8	399.7	9.56	36.67	40.87	87.10
U	102.6	18.63	58.9	5755	50.04	163.6	172.9	386.5	11.14	31.97	34.61	77.72
Ca-N	89.7	17.53	50.5	5144	47.40	162.5	138.3	220.8	10.23	34.44	29.86	74.55
LSD at 5%	22.7	1.68	11.22	976	N.S	.4416	N.S	N.S	356	N.S	N.S	N.S

AN= Ammonium nitrate AS= Ammonium sulfate U= Urea Ca-N= calcium nitrate

Plants readily take up and use two forms of soil nitrogen, ammonium ($NH_4^{+)}$ and nitrate (NO_3^-). Other forms of nitrogen must be converted to one of these compounds by natural or artificial means before plants can utilize them directly as a source of nitrogen for plant growth. The ammonium molecule (NH_4^+) carries a positive electrical charge and is attracted to the clay and organic matter in the soil, which carry negative charges. Once attached to the soil matrix, ammonium becomes part of the cation exchange process whereby plants exchange a hydrogen ion (H^+) for one of the positively charged molecules in the soil. Besides ammonium, other essential nutrients obtained by cation exchange include: potassium, calcium, magnesium, iron, manganese, and zinc. The urea form of nitrogen cannot be utilized directly by plants. It must first be converted to the ammonium form by chemical processes which, in turn, may be used by the plant or converted to the nitrate form by microbiological processes. The conversion of urea $\{CO(NH_2)_2\}$ to ammonium $(NH_4)^+$ occurs in a two step process. When the urea combines with water (hydrolyzes) it forms ammonium carbonate $(NH_4)_2CO_3$. Ammonium carbonate is unstable and decomposes to form ammonia gas (NH_3) and carbon dioxide (CO_2). The ammonia gas produced is chemically identical to anhydrous ammonia. If the ammonia gas is in physical contact with water, it reacts to form the ammonium ion $(NH_4)^+$. If the ammonium ion is in contact with the soil, it is attracted to the clay and organic matter particles and is held in the cation exchange complex (Dorn, 1996).

Ebert, *et al.* (2002) mentioned that addition of Ca $(NO_3)_2$ stimulated shoot growth more than root growth. Ca $(NO_3)_2$ Kurivts and Kirby (1980) revealed that there was little difference in growth between the two nitrogen treatments; these finding contrasts markedly with our own and other workers' observations that in static water cultures, NO_3-N is very often a preferential source for plant growth. Gulser (2005) demonstrated that increasing N doses as urea or ammonium sulfate increased the biomass of spinach plants

Majerowicz and Kerbauy (2002) reported that the nitrogen sources supplied (urea, nitrate and ammonium) affected dry matter accumulation in shoots and roots of both *C. fimbriatum* genotypes; however, they were not enough to change the characteristic pattern of dry matter partitioning of each genotype.

Interaction:

The interactive effects of nitrogen sources and irrigation intervals on growth of jatropha plants were presented in Table (4). Data show that this interaction effect on plant height, leaves number, fresh weight and dry weight was not significant. The highest number of leaves was by ammonium sulfate application when plants irrigated every 4 and 8 days however under 12 days' irrigation intervals the highest number was by ammonium nitrate or calcium nitrate. Area of leaves gave its higher values by addition of ammonium sulfate under 8 and 12 days intervals but under 4 days intervals it was by ammonium nitrate fertilization. For root dry weight, the highest dry weight by application of ammonium nitrate with irrigation every 4 and 12 days while under 8 irrigation intervals it was shown by plants received ammonium sulfate. Tolpu, *et al*. (2009) after experiments were conducted in each of three years considered as repeated units in a repeated measurement design, observed that fruit and total oil yields of olive increased about three times in highest irrigation and fertilization combination compared to rain fed and unfertilized treatments. Nevertheless, Driessche, *et al*. (2003) concluded that the adverse effect of fertilization on survival in the absence of irrigation was attributed to additional moisture stress caused by soluble fertilizer. Kant, *et al*. (2007) revealed that partial substitution of NO3- by NH4+ fertilization increases ammonium assimilating enzyme activities and reduces the deleterious effects of water stress on growth of barley. Ebert, *et al.* (2002) stated that in general, moderate $Ca(NO_3)_2$ supply (10 mM) had optimal effects on growth and metabolism of NaCl-stressed guava seedlings.

Table 4: Effect of nitrogen sources and irrigation stress on growth of jatropha plants

Ir.Intervals days	Source of N	Plant height (cm)	Root length (cm)	Leaves number	Leaves area cm	Fresh weight g				Dry weight g			
						Root	Stem	Leaves	Total	Root	Stem	Leaves	Total
4	Control	74.7	19.9	44.6	6655	64.8	207.6	143.5	415.9	10.39	34.32	35.48	80.20
	AN	109.7	20.7	69.4	8434	67.5	264.6	222.6	554.7	14.88	62.28	53.08	130.2
	AS	93.7	26.3	65.4	6989	51.6	182.2	177.7	411.5	9.11	38.16	40.38	87.65
	U	111.3	19.0	54.0	6579	47.8	173.4	198.6	419.8	13.85	34.38	38.24	107.0
	Ca-N	83.4	17.0	47.4	3340	35.9	149.0	120.2	305.1	9.04	31.95	18.94	82.44
8	Control	84.7	21.3	41.4	6823	52.6	141.4	124.8	318.8	15.92	37.81	36.99	90.72
	A.N	101.3	19.9	53.4	4563	36.1	194.7	137.8	368.6	7.13	32.07	27.52	66.72
	AS	108.3	23.0	61.4	9358	62.5	276.5	177.0	466.0	12.19	47.97	50.30	110.5
	U	99.3	19.9	64.6	4324	46.5	163.5	172.6	382.6	9.26	31.55	24.76	65.57
	CaN	92.8	14.3	51.4	5766	44.4	160.8	121.9	327.1	11.88	34.68	32.04	78.00
12	Control	86.0	18,7	46.6	5587	25.7	156.2	119.0	300.9	13.38	34.75	36.38	84.51
	A.N	109.3	21.3	65.4	6542	46.3	193.1	179.8	418.2	10.92	40.71	44.68	96.31
	AS	91.7	19.0	50.6	5403	36.9	147.9	136.7	321.5	7.39	23.89	31.88	63.16
	U	97.3	17.0	58.0	6345	56.9	153.9	147.6	358.4	10.32	29.98	40.84	81.14
	CaN	92.7	21.3	52.6	6333	52.9	177.8	172.8	403.5	9.83	36.70	38.86	85.39
LSD at 5%		N.S	2.91	N.S	1792	N.S	N.S	N.S	N.S	N.S	2215	N.S	N.S

AN= Ammonium nitrate AS= Ammonium sulfate U= Urea CaN= calcium nitrate

Mineral status:

Irrigation:

It was clearly shown that widening of irrigation intervals showed a positive effect on N, P and K concentration. The reverse was true for Mn and Cu concentration. Meanwhile, Fe and Zn concentration increase by the 1st irrigation widening and tended to decrease with the 2nd treatment of irrigation interval to be less than the control. Ca concentration was reversely responded (Table 5 and Fig.1). Furthermore, Na concentration was increased only by the more wide interval used. Concerning the uptake of different minerals, a negative relationship was detected on N, K, Fe, Mn and Zn uptake and prolonging of irrigation intervals and the reverse was true for Ca uptake while irrigation jatropha plants in 8 days frequency showed the highest values of Na and Cu uptake. Hu, *et al.* (2007) showed that the change in ion concentrate on along the growing leaf axis for most ions is independent of treatments. Although both drought and salinity cause a low nutrient availability in soil and low nutrient transport in plants, this study showed that except for Na^+, there was no difference in the concentrations of most ions at any given location between plants in the control and either of the drought or saline treatments. Sakr and Gaddalla (2009) reported that as for n, P and K content, it could be shown that drought treatment decreased N, P and K contents in leaves and stems of maize plants during the two growing seasons. Under the high drought stress treatments (20 days intervals), the most effective treatment in these three macronutrients was shown. Hussein, *et al.* (2009) on barely plants, observed the disturbance in minerals uptake by drought at different stage of growth. Hussein, *et al*. (2010) revealed that irrigation after depletion of available soil moisture affected the mineral status of fodder beet plants.

Table 5: Effect of irrigation intervals on mineral concentration of jatropha plants

Irrigation intervals days	Maco nutrients (%)					Micronutrients (ppm)			
	N	P	K	Ca	Na	Fe	Mn	Zn	Cu
4	2.35	0.27	2.01	3.23	1.08	352	351	485	39
8	2.26	0.20	2.37	3.76	1.07	268	371	470	60
12	2.40	0.26	2.14	4.06	1.17	209	280	412	42

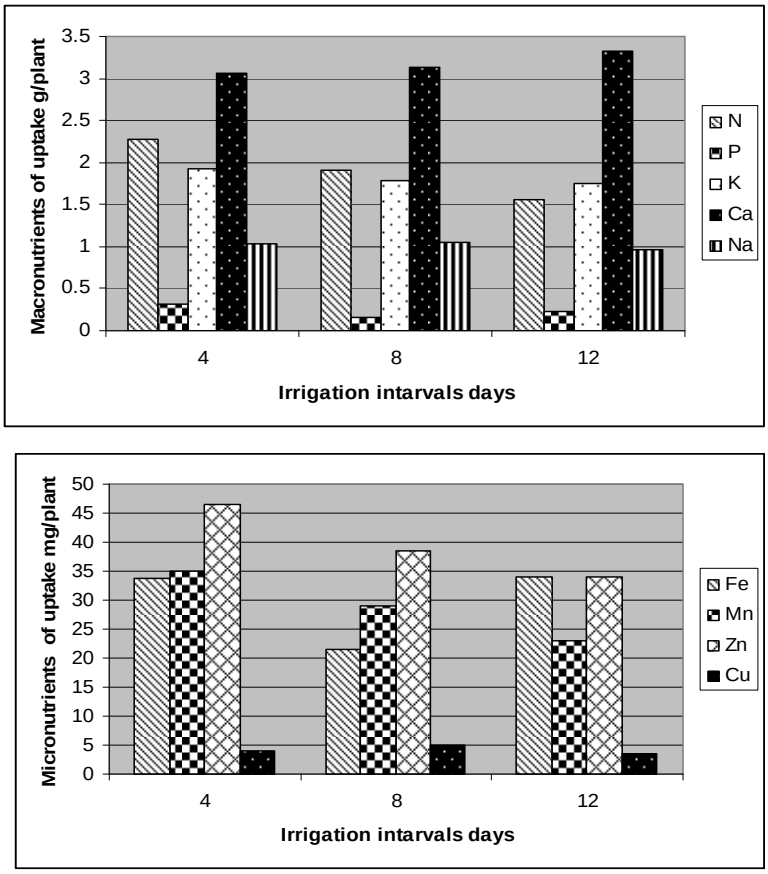


Fig. 1: Effect of irrigation intervals on mineral uptake of jatropha plants.

Nitrogen sources:

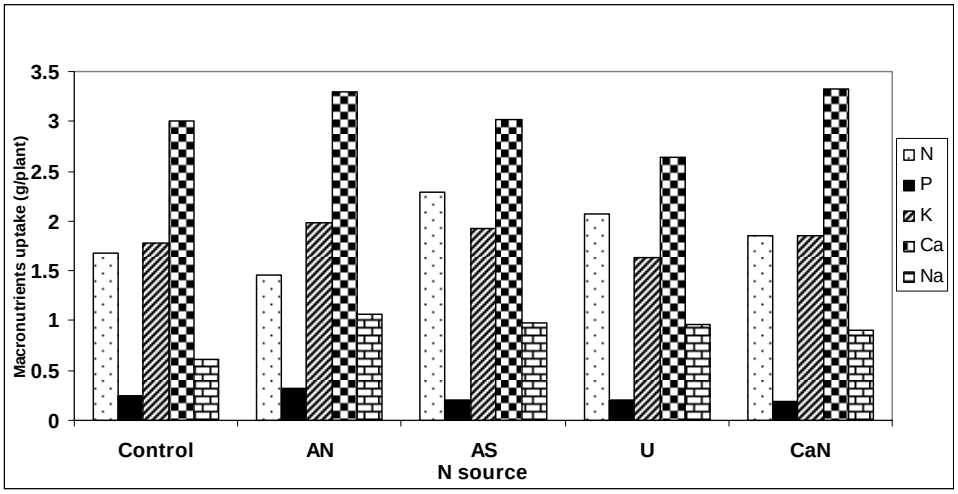
The highest values of N and Ca concentrations were obtained by application of AS, however, for P, Mn and Cu concentrations high values were by AN treatment. Data presented in Table (6 and Fig.2) indicated that AS showed the highest percentages of N, K, Ca, Na, Zn and Cu while AN gave the highest uptake of P and Mn but for Fe uptake it was in control plants. On reverse, the lowest uptake of N, P, K, Ca, Na, Mn and Cu was by application of calcium nitrate however for Fe uptake it was by addition of ammonium sulfate. Regardless the effect of irrigation frequency, the highest values of P, K, Mn, Na and Cu were by AN application, AS-fed plants showed the highest values of N and Zn uptake, however the highest Ca uptake was in plants received Ca-N. Nevertheless, the nitrogen fertilization with different sources caused a negative effect on Fe uptake. On the other hand, the lowest values of P, Mn, Zn and Cu uptake was shown in Ca-N fed plants, where U caused the lowest uptake of K and Ca. This lower values of uptake was observed on plants Fe with fed plants by AS and for Na uptake on plants without receiving any of nitrogen sources. Thwrios and Sakellariadis (1988) showed that as the level of No_3-N application was increased, P concentration tended to decreased whereas the opposite was observed in the case of NH_4-N. Potassium concentration was not affected to the same degree by the N form for all plant parts. Toshihiro, *et al.* (1998) noticed that the concentration of Al and P increased with the $+NH_4$ treatment. Nathawat, *et al*. (2007) mentioned that nitrogen application (120 kg/ha) in combined form had been found to maintain highest concentrations of N, P, Mg^{+2} and Ca^{2+} along with reduced concentrations of Na+ and SO_4^{-2}. However, reverse was true with ammoniacal form of nitrogen. Kudo and Fujyama (2010) reported that growth of NO^{-}_3 fed plants was regulated by N absorption. In contrast, N contents of shoots in NH^{+}_4 fed plants did not change with N concentration. Shoot Na content decreased with increasing N concentration, while K

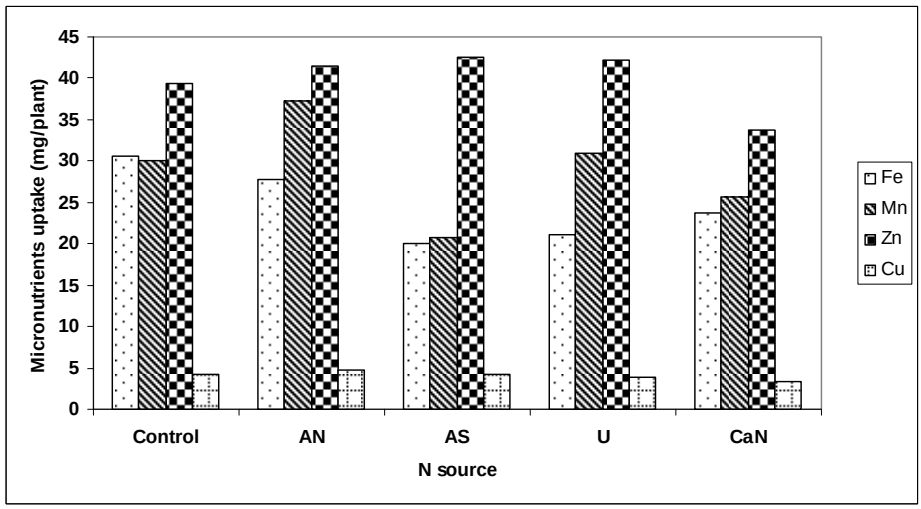
content increased. Dry weight was highly correlated only with K content in NH^{+}_{4} fed plants. These observations indicated that growth of NH^{+}_{4} fed plants was mainly regulated by K absorption. Kant, *et al.* (2007) reported that growth parameters were increased by application of NH_4^+/ NO_3^- compared to No_3^- alone. Differences in growth between the two nitrogen regimes were not due to differences in photosynthesis. Partial substitution of substitution of NO_3^- by NH_4^+ fertilization increases ammonium assimilating enzyme activities in barley plants.

Table 6: Effect of nitrogen sources on mineral concentration of jatropha plants

N	Maco nutrients (%)					Micronutrients (ppm)			
sources	N	P	K	Ca	Na	Fe	Mn	Zn	Cu
Control	1.97	0.29	2.08	3.51	1.08	350	351	468	50
An	2.39	0.31	2.12	3.33	1.09	284	382	430	52
As	2.64	0.23	2.22	4.12	1.13	225	248	485	46
U	2.41	0.24	1.90	3.19	1.14	292	370	506	47
CaN	2.29	0.23	2.26	4.07	1.10	288	278	395	41

AN= Ammonium nitrate AS= Ammonium sulfate U= Urea Ca-N= calcium nitrate





AN= Ammonium nitrate AS= Ammonium sulfate U= Urea CaN= calcium nitrate

Fig. 2: Effect of nitrogen sources on mineral uptake of jatropha plants.

Kotsiras, *et al.* (2002) found that the concentration of K, Ca, Mg and NO_3 in all regions of the fruit was higher when NO_3 constituted 75% or more of the total N in the nutrient medium, but was reduced by increasing concentrations of NH_4. The Mn content of the tissue in the central region of the fruit was reduced by NH_4 ions, whereas the Cu content of this tissue increased. No significant effect of N form on the B, Fe, Zn content of fruits was detected. Ebert, *et al.* (2002) observed that Ca $(NO_3)_2$ supplies increased leaf K^+ and Ca^{2+} concentration in guava leaves.

Kurivts and Kirby (1980) revealed that the total uptakes of K, Ca, Mg, Na and N (mg per plant) were also higher in the NO_3^-fed plants whereas for P, again, the reverse was the case. The mean rates of uptake of K, Ca, Mg and Na during the intervals between harvests, expressed per unit root length at each harvest, were all higher for the NO_3-fed plants. For P, however, the rate of uptake was higher by the NH_4-fed plants. Drake and White (1961) reported that as nitrogen increased cations exchange capacity was increased and this reflected in increase of Ca uptake by roots while potassium was decreased. Gulser (2005) found that increments in nitrogen doses of AS and urea from control to 150 kg N level ha^{-1} increased NO_3^-, NO_2^-, total N contents and yield of spinach significantly, but usually decreased P, Zn and Mn contents. NO_3^- contents of spinach in 120 and 150 kg N ha^{-1} of urea applications were higher than that of AS applications, while the NO_3^- contents of spinach in the lower application doses of AS were higher than that of urea applications. Increasing phosphorus availability in the higher doses of AS applications due to possibility of decreasing soil pH might be decrease NO_3^- accumulation in spinach by assimilating NO_3^- in protein form. NO_3^- and NO_2^- contents also gave the significant negative relationships with yield and P content in spinach. Decreasing micronutrient contents in spinach at the higher nitrogen doses might be due to dilution effect by increasing the plant biomass.

Interaction:

Data in table (7) showed that N concentration increased with all nitrogen sources when plants irrigated every 4 and 8 days, however , this element increased with spraying As and U on plants received water every 12 day. P% clearly affected with N sources in plants with 4 days intervals. K and Ca %gave its higher values by spraying As when irrigation applied at 4 days intervals. Under 8 days irrigation intervals, the higher values of K% resulted by AN and Ca by As application, while its higher concentration under wide irrigation intervals (12 days) and U and control treatments. Nevertheless, different nitrogen sources lowered Na concentration under 4 days irrigation frequency.

On reverse, this nutrient concentration raised with Ca N fertilizer and irrigation applied in 8 as well as 12 days intervals.

Concerning the micronutrients, there was a negative relation between N sources and concentration of Mn and Zn under irrigation every 4 days while the reverse was true for Fe and Mn in 12 days irrigation treatment. Meanwhile, under irrigation every 8 days Fe and Mn showed the same response of its concentration under the lesser irrigation frequency used. All irrigation treatments and application of As led to the higher Cu concentration in jatropha plant tissues.

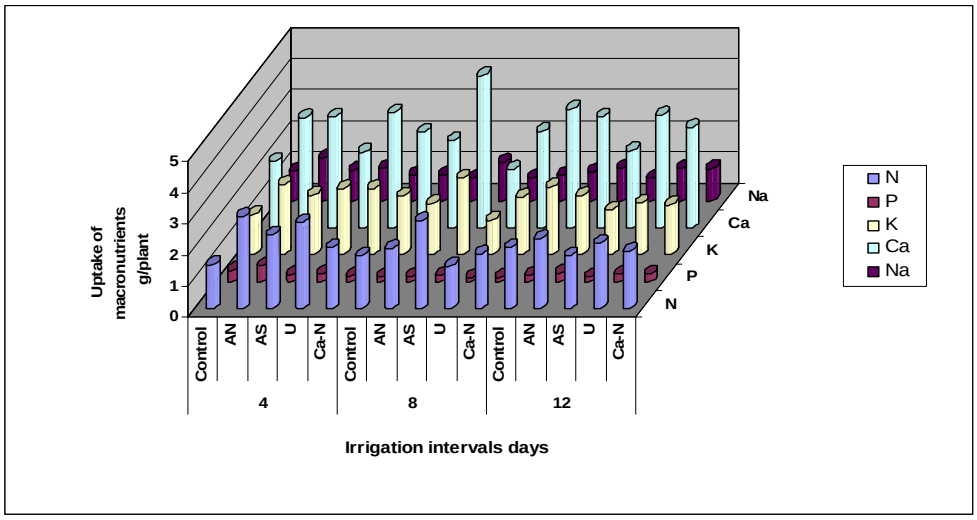
The interactive effect of nitrogen sources and irrigation intervals on minerals uptake were illustrated in Table 7 and Fig 3&4. Data showed that N uptake increased by fertilizing with ammonium nitrate, ammonium sulfate and urea and the highest increase was by ammonium nitrate the reverse was true for used of calcium nitrate whereas N value is lesser than in the control plants under irrigation every 4 days. Moreover, the positive effect of fertilizing with ammonium nitrate, ammonium sulfate and urea were shown also in K, Fe, Mn and Cu uptake. The highest effect was by application of AN on Na, Mn and Cu while for Zn and Fe was by application of U but for Ca by As fertilizer. The effect in these elements by fertilization with calcium nitrate was lesser than the others nitrogen sources. Under 8 days irrigation intervals, the highest value of N uptake was by applied ammonium sulfate and the lowest was by urea application, however for K, Ca, Na and Cu by application of AS. However, under 12 days intervals N uptake increased only by ammonium nitrate and urea. The highest K uptake were observed when plants received ammonium sulfate and the lowest by Urea and irrigation every 8 days While when plants irrigated 12 days intervals all nitrogen sources decreased K and Ca uptake.

Table 7: Effect of irrigation intervals and nitrogen sources on mineral concentration of jatropha plants

Irrigation intervals days	N Sources	Maco nutrients (%)					Micronutrients (ppm)			
		N	P	K	Ca	Na	Fe	Mn	Zn	Cu
4	Control	1.76	0.45	1.59	2.65	1.21	466	408	530	31
	An	2.26	0.39	1.73	2.70	1.06	295	409	393	39
	As	2.69	0.26	2.18	4.06	1.13	284	228	515	50
	U	2.57	0.24	1.98	2.26	0.99	386	378	515	40
	CaN	2.37	0.23	2.56	4.48	1.02	327	332	474	39
8	Control	1.86	0.18	2.07	3.38	0.92	506	472	458	69
	An	2.88	0.25	2.46	4.20	1.10	296	426	442	75
	As	2.55	0.19	2.22	4.41	1.11	95	210	485	58
	U	2.08	0.20	1.67	2.85	1.14	215	459	628	53
	CaN	2.24	0.18	2.37	3.98	1.06	226	267	338	44
12	Control	2.31	0.25	2.57	4.49	1.10	79	172	400	49
	An	2.32	0.28	1.96	3.69	1.10	260	310	456	43
	As	2.68	0.24	2.26	3.91	1.15	295	306	454	30
	U	2.58	0.29	2.04	4.46	1.28	97	274	375	47
	CaN	2.16	0.29	1.86	3.76	1.21	312	336	394	40

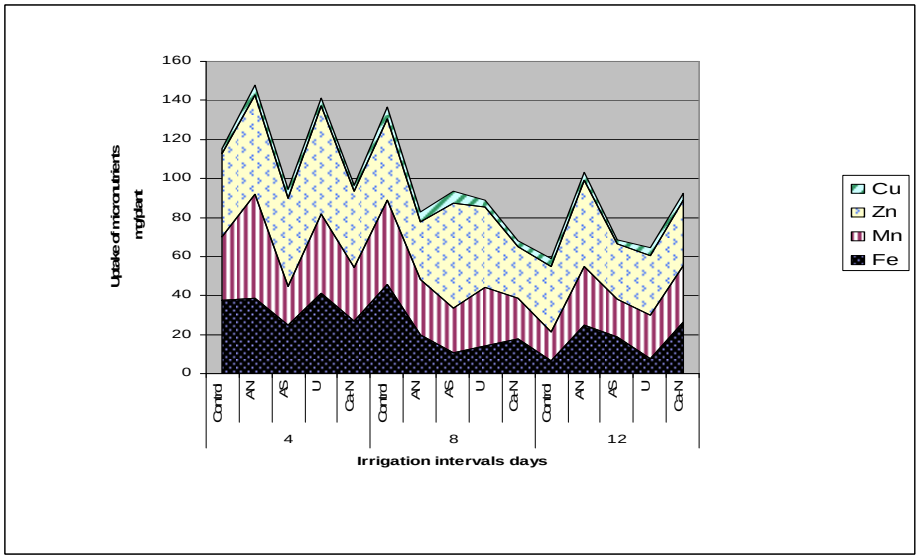
AN= Ammonium nitrate AS= Ammonium sulfate U= Urea CaN= calcium nitrate

Icher, *et al.* (2003) stated that for all irrigation treatments, the % recovery of N in the whole plant was higher in plants that received ^{15}N at tailoring (63%, 49% respectively for irrigation intervals between 10 and 30 d) than in plants that received ^{15}N just after seeding (28% for irrigation each 10 and 30 days intervals). For the irrigation treatment each 10 and 15 days, the ^{15}N was mainly recovered by the grain for all fertilization treatments, whereas for irrigation treatment each 30 days, the grain and straw recovered nearly equal amounts of fertilizer.



AN= Ammonium nitrate AS= Ammonium sulfate U= Urea CaN= calcium nitrate

Fig. 3: Effect of irrigation intervals and nitrogen sources on macro-nutrients uptake of jatropha plants.



AN= Ammonium nitrate AS= Ammonium sulfate U= Urea CaN= calcium nitrate

Fig. 4: Effect of irrigation intervals and nitrogen sources on micro-nutrients uptake of jatropha plants.

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