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EFFECT OF IRRIGATION INTERVALS AND ORGANIC/MINERAL FERTILIZATION TREATMENTS ON VEGETATIVE GROWTH AND CHEMICAL COMPOSITION OF *MORINGA OLEIFERA* PLANTS

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ABSTRACT

A field experiment was conducted to explore the influence of three irrigation intervals and six organic and/or mineral NPK fertilization treatments on vegetative growth characters and chemical composition of *Moringa oleifera* plants. Obtained results showed that all studied vegetative growth characters, plant height, stem diameter, branch number and leaves number, fresh and dry weights were gradually increased parallel to the gradual shortening in irrigation intervals. On the contrary, the three photosynthetic pigments, chlorophyll a, chlorophyll b and carotenoids, as well as, the leaves % of nitrogen, phosphorus, potassium, calcium and magnesium were increased parallel to prolonging the irrigation intervals. Concerning organic/mineral NPK fertilization treatments, the highest vegetative growth characters and chemical constituents were given by the 100 % organic followed by 75 % organic + 25 % NPK treatments in comparison with all other treatments including control plants. In regard to the interaction between irrigation intervals and fertilization treatments, the best overall growth characters were obtained due to irrigation *Moringa oleifera* plants at the short interval (every 14 days) and supplied the plants with 100 % organic fertilizer (4 kg poultry manure/plant).

INTRODUCTION

Moringa oleifera, Lam. (Family: Moringaceae) is native to North India but it is now found throughout the tropics. It is wide adaptability and ease of establishment. It can be found in India, Arabia, Africa, America, as well as, Sri Lanka, Malaysia and the Philippines. The tree is often referred to as a wonder tree for its multipurpose usability (Verdcourt, 1985). Its leaves, pods and flowers are packed with nutrients important to both human and animals (Dalla, 1993). *Moringa oleifera* is a relatively fast growing tree which can grow more than 10 m high and is topped by a crown in the shape of an umbrella. The leaves are small (1-2 cm) and can be found at markets. The pods are long drumstick shaped that contain the seeds. The pods are green and tender at first and then turned dark and solid. Moringa is used as food, fodder and for medicinal purposes. The leaves are an excellent source of vitamins (A, B and C), minerals (calcium and iron) and protein (Sixl-Daniell *et al.*, 2011) and can be eaten as soup, greens, sauces, salads, curries, pickles and seasoning. Pressing the seeds gives edible oil which is clear, sweet, does not become rancid and is used for manufacturing perfumes and hairdressings. Moringa seeds can furthermore be used for water purification purposes. Concerning cultivation, Moringa can be propagated from seeds or cuttings. It is grown mainly in semiarid, tropical and subtropical areas. It grows best in dry sandy soil and tolerates poor soil including coastal areas. Moringa is a sun and heat-loving plant, and thus does not tolerate freeze or frost (Raja *et al*., 2013).

The influence of irrigation quantity on vegetative growth characters and chemical composition of Moringa trees was reported by Dalla-Rosa (1993), Ali (2014) and Sale *et al.* (2015) on Moringa. Similar findings were reported on other woody plants such as *Cupressus* and *Eucalyptus* (Shehata, 1992), *Eucalyptus* (El-Tantawy *et al*., 1993), Khaya (Sayed, 2001) and jojoba (Uday *et al*., 2001 and Ibrahim, 2005). While, the role of organic fertilization was pointed out by Foidl *et al*. (2001), Beaulah *et al*. (2004), Pamo *et al*. (2005), Chadha *et al*. (2007), Probhaker and Hebber (2007), Oliveira Junior *et al*. (2009), Isaolu *et al*. (2012), Fagbenro *et al.* (2013) and Ndubuaku *et al*. (2014) on Moringa; Ali *et al*. (2001) on Khaya and Badran *et al*. (2003) on *Acacia saligna*. Meanwhile, a good number of authors demonstrated the importance of NPK mineral fertilizers in augmenting growth and chemical composition of different woody plants such as Beaulah *et al*. (2004), Pamo *et al.* (2005), Fagbenro *et al*. (2013), Pahla *et al.* (2013) and Mendieta-Araica *et al*. (2013) on Moringa; Sayed (2001) and Darwesh *et al.* (2011) on Khaya; Mahdy (2002) on *Melia* and *Albizzia*, Larimer and Strove (2002) on *Acer* and *Quercus*; Badran *et al.* (2003) on *Acacia saligna*; Helmy (2010) on jojoba and Shetta *et al.* (2014) on *Leucaena*.

MATERIALS AND METHODS

The present experiment was conducted at El-Mataana Exp. Station, Luxor during two successive seasons 2013 and 2014 to explore the effect of three irrigation intervals and six organic/mineral fertilization treatments on vegetative growth and chemical composition of *Moringa oleifera* plants.

The seedlings, 30 cm height and 0.7 cm diameter, were planted on March 5 of both seasons in 2×6 m plots with 2 m distance between rows, so, each plot included 3 plants. The experiment was arranged in split-plot design with three replicates. The main plot included three irrigation intervals (every 14, 21 and 28 days) and the sub-plot contained six organic and/or NPK mineral fertilization treatments (control, 100 % NPK, 100 % organic, 75 % organic + 25 % NPK, 50 % organic + 50 % NPK and 25 % organic + 75 % NPK). One meter diameter ditch was digged between each two irrigation treatments. Physical and chemical analysis of the soil (0-30 cm) are presented in Table (a).

Table (a): Physical and chemical analysis of the soil :

Properties	Value	Properties	Value
Coarse sand (%)	1.25	Na (meq/100 g soil)	0.80
Fine sand (%)	33.19	K (meq/100 g soil)	0.20
Silt (%)	29.50	Soluble anions (1:2.5 Abstract)	
Clay (%)	36.06	CO_3 (meq/100 g soil)	0.11
Texture	Clay loam	HCO_3 (meq/100 g soil)	0.59
Soil pH	7.90	Cl (meq/100 g soil)	0.28
E.C. (mmhose/cm)	0.51	SO_4 (meq/100 g soil)	0.88
Soluble cations (1:2.5 Abstract)		Available N (ppm)	6.0
Ca (meq/100 g soil)	0.72	P (ppm)	17.0
Fe (meq/100 g soil)	7.00	K (ppm)	67.0
Cu (meq/100 g soil)	1.14	CEC (meq/100 g soil)	38.52
Mn (meq/100 g soil)	1.40	O.M. (%)	1.83
Zn (meq/100 g soil)	0.70	CaCO3 (%)	3.50
Mg (meq/100 g soil)	0.61		

Irrigation was done regularly from the planting date (March, 5) and up to June, 1st to all seedlings as needed. Then irrigation interval treatments were started on the first of June, for both seasons, and up to the end of Sept. Such irrigation treatments were applied by amounts of water up to the field capacity for each interval treatment. These amounts of water were supplied by water counter according to the following Table (b)

Table (b): Amounts of water during the experimental period for both seasons :

Interval treatments	Amounts of water (m^3/12 m^2 plot)		
	June	July-Aug.	Sept.
Every 14 days	24	28	20
Every 21 days	33	38	28
Every 28 days	36	42	30

The one hundred (100 %) organic treatment was applied at the rate of 4 kg/plant in the form of poultry manure. Mineral NPK treatment (100 %) was consisted of 300 g/plant of ammonium nitrate (33 % N), 150 g/plant of calcium superphosphate (15.5 % P_2O_5) and 50 g/plant potassium sulphate (50 % K_2O). The phosphorus fertilizer amounts were added once before planting, while, N and K fertilizers were divided into 3 batches and added after one month from planting and every 4 weeks thereafter according to irrigation interval treatments. All other agricultural treatments were done as usual.

At the end of the experiment, on the third week of Sept. of both seasons, the data were recorded for plant height (cm), stem diameter (10 cm above soil surface in cm), branch number/plant and number, fresh weight and dry weight of leaves/plant. In addition, chemical analysis was done for the three photosynthetic pigments chlorophyll a, chlorophyll b and carotenoids contents on the first week of Sept. following the methods described by Fadl and Seri-Eldeen (1978). While, the five mineral nutrients N, P, K, Ca and Mg %, were determined in the dry leaves according to Page *et al.* (1982).

All vegetative growth characters and chemical composition determinations were statistically analyzed following the L.S.D. method described by Little and Hills (1978).

RESULTS AND DISCUSSION

1-Vegetative growth characters:

Tables (1 and 2) showed that all studied vegetative growth characters, vegetative traits, in the two seasons, i.e. plant height, stem diameter, branch number/plant and leaves number, fresh weight and dry weight/plant were significantly increased by decreasing the irrigation interval. Such increase was gradual parallel to the irrigation interval with the highest values being given, in the two seasons, due to the short irrigation interval (every 14 days). Numerically, plant height, stem diameter, branch number/plant, leaf number/plant, leaves fresh weight/plant, leaves dry weight/plant, for the 28. 21 and 14 days interval irrigation treatments, recorded 220, 266 and 289 cm; 3.22, 4.09 and 4.29 cm; 4.11, 6.39 and 7.39; 93, 125 and 164; 4.32, 6.50 and 9.40 g and 1.09, 1.82 and 2.85 g, respectively, in the first season. The same trend was observed in the second season as shown in Tables (1 and 2). These results are in accordance with the findings reported by Dalla-Rosa (1993), Ali (2014) and Sale *et al.* (2015) on Moringa; Shehata (1992) on *Cupressus* and *Eucalyptus* and Uday *et al.* (2001) on jojoba.

Concerning organic and/or NPK mineral fertilization, all prementioned growth characters were significantly augmented, in both seasons, due to the application of any one of the five organic and/or mineral fertilization treatments in comparison with unfertilized control treatment as shown in Tables (1 and 2).

Among the five organic/NPK treatments, the highest values for all were obtained, in descending order, from 100 % organic, 75 % organic + 25 % NPK, 50 % organic + 50 % NPK, 25 % organic + 75 % NPK and 100 % NPK. The treatments of 100 % organic and that of 100 % NPK increased plant height, stem diameter, branch number, leaf number, leaves fresh weight and leaves dry weights by 64.9 and 35.1 %, 87.1 and 72.8, 169.1 and 113.5 %, 206.3 and 189.6 %, 336.4 and 243.4 % and 290.3 and 216.1 %, respectively over that of control treatment in the first season with almost similar trend being obtained in the second season. The positive response of Moringa to organic fertilization was revealed by Foidl *et al.* (2001), Chadha *et al*. (2007), Probhaker and Hebber (2007), Oliveira Junior *et al.* (2009), Isaolu *et al*. (2012), Fagbenro *et al.* (2013) and Ndubuaku *et al.* (2014). While, that of NPK was reported by Beaulah *et al*. (2004), Pamo *et al.* (2005), Fagbenro *et al*. (2013) and Pahla *et al.* (2013) on Moringa; Larimer and Struve (2002) on *Acer* and *Quercus* and Shetta *et al.* (2014) on *Leucaena*.

Concerning the interaction between irrigation intervals and organic/NPK fertilization treatments, the longest plants, thickest stems, highest number of branches and leaves/plant and heaviest leaves fresh and dry weights/plant were obtained by irrigating Moringa plants every 14 days and supplied them with 100 % organic or 75 % organic + 25 % NPK fertilizers. Such two combined treatments gave significantly the highest values, in both seasons, over almost all other treatments including control ones as clearly illustrated in Tables (1 and 2).

2- Photosynthetic pigments:

The three photosynthetic pigments, chlorophyll a, chlorophyll b and carotenoids contents were significantly increased due to prolonging the irrigation interval in the two seasons as shown in Table (3). Such increase was gradual parallel to the increase in the irrigation interval. In accordance with these results were those revealed by El-Tantawy *et al*. (1993), Sayed (2001) and Ibrahim (2005) on *Eucalyptus*, *Khaya* and jojoba, respectively.

In regard to organic/NPK fertilization treatments, significant differences were obtained between control plants and the treatments of 100 % organic and 75 % organic + 25 % NPK in both seasons in favour of fertilization treatments for each of chlorophyll a, chlorophyll b and carotenoids contents as shown in Table (3). In agreement with these results were the findings of Badran *et al*. (2003) on *Acacia saligna* concerning organic fertilization and those of Sayed (2001) on *Khaya*, Mahdy (2002) on *Melia* and *Albizzia*, Badran *et al*. (2003) on *Acacia saligna*, Helmy (2010) on jojoba and Darwesh (2011) on *Khaya*, in regard to NPK fertilization.

In regard to the interaction between the two studied factors, no significant differences were obtained in both seasons, Table (3). However, a clear trend of increasing the three photosynthetic pigments due to irrigating the plants at the long period (every 28 days) and supplied them with 100 % organic or 75 % organic + 25 % NPK fertilization.

Table (1): Effect of irrigation intervals and mineral NPK/organic fertilization treatments on vegetative growth of *Moringa oliefera* plants during 2013 and 2014 seasons

Org./NPK fertilization (B)	Irrigation interval treatments (days) (A)							
	1st season				2nd season			
	28	21	14	Mean B	28	21	14	Mean (B)
Plant height (cm)								
Control	146	184	224	185	152	189	228	189
100 % NPK	202	261	288	250	205	266	290	254
100 % Org.	268	318	328	305	274	323	332	310
¾ Org. + ¼ NPK	261	288	311	287	265	292	317	291
½ Org. + ½ NPK	235	284	294	271	261	289	296	282
¼ Org. + ¾ NPK	206	263	290	253	223	267	293	261
Mean (A)	220	266	289		230	271	293	
L.S.D. at 5 %	A: 20	B: 24		AB: 41	A: 19	B: 21		AB: 35
Stem diameter at 10 cm above soil (cm)								
Control	1.69	2.46	2.82	2.32	1.73	2.50	2.85	2.36
100 % NPK	3.39	4.25	4.40	4.01	3.53	4.38	4.45	4.12
100 % Org.	3.65	4.58	4.79	4.34	3.70	4.61	4.83	4.38
¾ Org. + ¼ NPK	3.60	4.46	4.72	4.26	3.66	4.50	4.76	4.31
½ Org. + ½ NPK	3.56	4.40	4.56	4.17	3.60	4.43	4.60	4.21
¼ Org. + ¾ NPK	3.43	4.37	4.47	4.09	3.57	4.39	4.50	4.16
Mean (A)	3.22	4.09	4.29		3.30	4.14	4.33	
L.S.D. at 5 %	A: 0.34	B:0.21		AB: 0.36	A: 0.29	B:0.17		AB: 0.29
Branch number/plant								
Control	1.13	3.11	4.00	2.75	1.20	3.20	4.12	2.84
100 % NPK	4.09	6.42	7.11	5.87	4.16	6.50	7.23	5.96
100 % Org.	5.44	7.72	9.04	7.40	5.56	7.82	9.16	7.51
¾ Org. + ¼ NPK	5.00	7.31	8.46	6.92	5.06	7.43	8.63	7.04
½ Org. + ½ NPK	4.63	7.08	8.10	6.60	4.70	7.16	8.20	6.69
¼ Org. + ¾ NPK	4.39	6.71	7.62	6.24	4.46	6.76	7.76	6.33
Mean (A)	4.11	6.36	7.39		4.19	6.65	7.52	
L.S.D. at 5 %	A: 0.52	B:0.40		AB: 0.69	A: 0.48	B:0.39		AB: 0.68

3- Leaves % of N, P, K, Ca and Mg:

Tables (4 and 5) showed that each of phosphorus and potassium % were significantly and gradually increased, in the two seasons, due to prolonging the irrigation interval as the long treatment (28 days) giving the highest values. The other three nutrients, N, Ca and Mg took the same trend but with no significant differences as illustrated in Tables (4 and 5). In close agreement with these results were those given by El-Tantawy *et al.* (1993) on *Eucalyptus*, Sayed (2001) on *Khaya* and Ibrahim (2005) on jojoba.

Table (2): Effect of irrigation intervals and mineral NPK/organic fertilization treatments on vegetative growth of Moringa oliefera plants during 2013 and 2014 seasons

Org./NPK fertilization (B)	Irrigation interval treatments (days) (A)							
	1st season				2nd season			
	28	21	14	Mean (B)	28	21	14	Mean (B)
	Number of leaves/plant							
Control	26	54	65	48	33	60	70	55
100 % NPK	102	135	179	139	110	141	186	145
100 % Org.	110	143	188	147	117	149	194	153
¾ Org. + ¼ NPK	108	142	186	145	115	146	192	151
½ Org. + ½ NPK	107	139	183	143	112	144	190	149
¼ Org. + ¾ NPK	105	138	181	141	110	143	188	147
Mean (A)	93	125	164		100	130	170	
L.S.D. at 5 %	A: 8	B: 6		AB: 10	A: 8	B: 6		AB: 11
	Leaves fresh weight /plant (kg)							
Control	1.07	2.02	2.85	1.98	1.14	2.08	3.24	2.15
100 % NPK	4.37	6.64	9.40	6.80	4.41	6.70	10.00	7.04
100 % Org.	5.73	8.27	11.91	8.64	5.78	8.31	11.96	8.68
¾ Org. + ¼ NPK	5.28	7.75	11.31	8.11	5.34	7.83	11.39	8.19
½ Org. + ½ NPK	4.95	7.35	10.66	7.65	4.99	7.41	10.84	7.75
¼ Org. + ¾ NPK	4.54	6.98	10.29	7.27	4.58	7.10	10.41	7.36
Mean (A)	4.32	6.50	9.40		4.37	6.57	9.64	
L.S.D. at 5 %	A: 0.47	B:0.32		AB: 0.55	A: 0.58	B:0.42		AB: 0.73
	Leaves dry weight/plant (kg)							
Control	0.30	0.59	0.98	0.62	0.33	0.62	1.06	0.67
100 % NPK	1.12	1.82	2.93	1.96	1.18	1.94	3.07	2.06
100 % Org.	1.42	2.28	3.57	2.42	1.48	2.34	3.66	2.49
¾ Org. + ¼ NPK	1.33	2.22	3.36	2.30	1.38	2.22	3.44	2.35
½ Org. + ½ NPK	1.23	2.12	3.18	2.18	1.30	2.13	3.24	2.22
¼ Org. + ¾ NPK	1.16	1.91	3.05	2.04	1.22	2.02	3.10	2.11
Mean (A)	1.09	1.82	2.85		1.15	1.88	2.93	
L.S.D. at 5 %	A: 0.15	B: 0.22		AB: 0.38	A: 0.18	B: 0.20		AB: 0.35

In relation to organic/NPK fertilization treatments, significant differences were obtained among the six tested organic and/or NPK fertilization treatments, in both seasons, for nitrogen, phosphorus and potassium %. The two treatments of 100 % organic and 75 % organic + 25 % NPK surpassed all other treatments and gave significantly higher values than control and 100 % NPK treatments in both seasons, as shown in Table (4). In regard to calcium and magnesium %, they followed the same trend like that of N, P and K but the differences did not reach the level of significance, as shown in Table (5). The role of organic fertilization in augmenting N, P, K, Ca and Mg was emphasized by Pamo *et al*. (2005) on Moringa, Ali *et al.* (2001) on *Khaya* and Badran *et al*. (2003) on *Acacia saligna*. While that of NPK fertilization was reported by Mendieta-Araica *et al*. (2013) on Moringa, Mahdy (2002) on *Melia* and *Albizzia* and Badran *et al.* (2003) on *Acacia saligna*.

Table (3): Effect of irrigation intervals and mineral NPK/organic fertilization treatments on photosynthetic pigments of *Moringa oliefera* plants during 2013 and 2014 seasons.

Org./NPK fertilization (B)	Irrigation interval treatments (days) (A)							
	1st season				2nd season			
	28	21	14	Mean(B)	28	21	14	Mean(B)
Chlorophyll a content mg/g F.W.								
Control	2.43	2.36	2.31	2.37	2.37	2.30	2.26	2.31
100 % NPK	2.47	2.41	2.35	2.41	2.42	2.36	2.31	2.36
100 % Org.	2.51	2.45	2.41	2.46	2.48	2.42	2.37	2.42
¾ Org. + ¼ NPK	2.50	2.44	2.39	2.45	2.46	2.40	2.35	2.40
½ Org. + ½ NPK	2.49	2.42	2.37	2.43	2.45	2.39	2.34	2.39
¼ Org. + ¾ NPK	2.49	2.42	2.36	2.42	2.44	2.37	2.33	2.38
Mean (A)	2.48	2.42	2.37		2.44	2.38	2.33	
L.S.D. at 5 %	A: 0.08	B:0.06		AB: N.S.	A: 0.08	B:0.07		AB: N.S.
Chlorophyll b content mg/g F.W.								
Control	1.66	1.61	1.56	1.61	1.58	1.52	1.48	1.53
100 % NPK	1.69	1.65	1.59	1.64	1.61	1.56	1.51	1.56
100 % Org.	1.75	1.69	1.64	1.69	1.66	1.60	1.55	1.60
¾ Org. + ¼ NPK	1.74	1.69	1.63	1.69	1.64	1.58	1.54	1.59
½ Org. + ½ NPK	1.73	1.67	1.63	1.68	1.63	1.58	1.53	1.58
¼ Org. + ¾ NPK	1.72	1.66	1.61	1.66	1.62	1.56	1.51	1.56
Mean (A)	1.72	1.66	1.61		1.62	1.57	1.52	
L.S.D. at 5 %	A: 0.05	B:0.05		AB: N.S.	A: 0.06	B:0.05		AB: N.S.
Carotenoids content mg/g F.W.								
Control	1.97	1.93	1.88	1.93	1.84	1.80	1.74	1.79
100 % NPK	2.04	2.01	1.94	2.00	1.87	1.84	1.77	1.83
100 % Org.	2.11	2.05	2.00	2.05	1.92	1.88	1.83	1.88
¾ Org. + ¼ NPK	2.08	2.03	1.96	2.03	1.91	1.87	1.81	1.86
½ Org. + ½ NPK	2.08	2.02	1.95	2.02	1.89	1.87	1.79	1.85
¼ Org. + ¾ NPK	2.06	2.01	1.95	2.01	1.88	1.85	1.78	1.84
Mean (A)	2.06	2.01	1.95		1.89	1.85	1.79	
L.S.D. at 5 %	A: 0.03	B:0.07		AB: N.S.	A: 0.06	B:0.06		AB: N.S.

The interaction between irrigation intervals and organic/NPK fertilization treatments was significant for nitrogen and potassium only, while, the same trend was observed for phosphorus, calcium and magnesium without significance differences. These results proved to be true in the two seasons, as shown in Tables (4 and 5). The highest overall values for N, P, K, Ca and Mg leaves % were given due to the long irrigation interval (28 days) in combination with 100 % organic or 75 % organic + 25 % NPK fertilization treatments, as clearly shown in Tables (4 and 5)

The effect of the three factors examined in the present experiment, water quantity, organic and mineral fertilization treatments on growth and chemical constituents of *Moringa oleifera* plants could be explained, physiologically in the light of their roles on such characters. Water supply is the essential factor in plant/water relationships for maintaining sufficient high water content to permit normal functioning of physiological process and growth. The importance of water in the life of trees, according to Kramer and Kozlowski (1960) included four main functions, i.e. a constituent of protoplasm, a reagent in photosynthesis and digestion, a solvent and to maintain turgidity. Therefore, adequate amounts of water supply are essential for plant growth and development as indicated in the present study in sort of plant height, stem diameter, branch number, leaf number and leaves fresh and dry weights. Meanwhile, the reduction in the three photosynthetic pigments content and leaves N, P, K, Ca and Mg % by increasing water supply could be attributed to the so-called dilution effect, which means that the increase in the leaves weight was much more higher than the stimulation of the chemical constituents.

The role of organic fertilization in enhancing different vegetative growth traits and chemical constituents could be attributed to its capability in increasing total N, organic matter and humus in the soil, improving soil properties and water holding capacity, making most micronutrients more readily available at a wide range of pH and accelerating the release of essential nutrients by microbial decomposition, (Follet *et al*., 1981). On the other side, the role of NPK mineral fertilization in promoting different vegetative growth characters could be explained in the light of the important physiological roles of each of N, P and K nutrients as mentioned by many scientists. Nitrogen is a constituent of different organic compounds which are very important for plant growth. Phosphorus is essential for cell division and meristem tissue development. It is involved in the processes of phosphorylation, enzymatic reactions and is a constituent of NAD and NADP.

Potassium is essential for nitrogen metabolism and protein synthesis, maintaining the osmotic concentration, cell turgidity, stomatal movement and water relations and metabolism and translocation of carbohydrates. The increase in the leaves content of photosynthetic pigments and N, P, K, Ca and Mg due to NPK fertilizers might be due to the fact that nitrogen is an important constituent of chlorophyll molecule, cytochrome, and proteins, (Bidwell, 1974).

Table (4): Effect of irrigation intervals and mineral NPK/organic fertilization treatments on leaves % of N, P and K of *Moringa oliefera* plants during 2013 and 2014 seasons.

Org./NPK fertilization (B)	Irrigation interval treatments (days) (A)							
	1st season				2nd season			
	28	21	14	Mean(B)	28	21	14	Mean(B)
Leaves nitrogen %								
Control	2.46	2.42	2.39	2.42	2.56	2.51	2.48	2.52
100 % NPK	2.51	2.46	2.45	2.47	2.64	2.61	2.58	2.61
100 % Org.	2.72	2.68	2.65	2.68	2.85	2.83	2.81	2.83
¾ Org. + ¼ NPK	2.70	2.66	2.63	2.66	2.79	2.75	2.73	2.76
½ Org. + ½ NPK	2.64	2.61	2.59	2.61	2.76	2.71	2.69	2.72
¼ Org. + ¾ NPK	2.57	2.53	2.49	2.53	2.72	2.67	2.63	2.68
Mean (A)	2.60	2.56	2.53		2.72	2.68	2.65	
L.S.D. at 5 %	A: N.S.	B:0.07	AB: 0.11		A: N.S.	B:0.08	AB: 0.13	
Leaves phosphorus %								
Control	0.268	0.247	0.241	0.252	0.284	0.266	0.259	0.270
100 % NPK	0.274	0.251	0.248	0.258	0.290	0.272	0.267	0.276
100 % Org.	0.293	0.279	0.270	0.281	0.311	0.297	0.288	0.299
¾ Org. + ¼ NPK	0.288	0.270	0.265	0.274	0.308	0.288	0.281	0.292
½ Org. + ½ NPK	0.281	0.265	0.260	0.269	0.301	0.281	0.279	0.287
¼ Org. + ¾ NPK	0.278	0.258	0.251	0.262	0.296	0.278	0.272	0.282
Mean (A)	0.276	0.262	0.256		0.298	0.280	0.274	
L.S.D at 5%	A: 0.008	B:0.011	AB: N.S.		A: 0.006	B:0.012	AB: N.S.	
Leaves potassium %								
Control	1.59	1.49	1.45	1.51	1.69	1.55	1.52	1.59
100 % NPK	1.71	1.62	1.58	1.64	1.75	1.66	1.65	1.69
100 % Org.	1.88	1.79	1.77	1.82	1.99	1.90	1.88	1.92
¾ Org. + ¼ NPK	1.83	1.75	1.70	1.76	1.90	1.81	1.77	1.83
½ Org. + ½ NPK	1.79	1.69	1.67	1.72	1.87	1.77	1.74	1.80
¼ Org. + ¾ NPK	1.75	1.65	1.62	1.67	1.81	1.73	1.69	1.74
Mean (A)	1.76	1.67	1.63		1.84	1.74	1.71	
L.S.D. / 5 %	A: 0.06	B:0.07	AB: 0.12		A: 0.07	B:0.07	AB: 0.12	

Table (5): Effect of irrigation intervals and mineral NPK/organic fertilization treatments on leaves % of Ca and Mg of *Moringa oliefera* plants during 2013 and 2014 seasons.

Org./NPK fertilization (B)	Irrigation interval treatments (days) (A)							
	1st season				2nd season			
	28	21	14	Mean (B)	28	21	14	Mean (B)
				Leaves calcium %				
Control	1.02	0.98	0.97	0.99	1.10	1.07	1.06	1.08
100 % NPK	1.03	1.00	0.98	1.00	1.11	1.08	1.07	1.09
100 % Org.	1.06	1.03	1.01	1.03	1.14	1.11	1.10	1.12
¾ Org. + ¼ NPK	1.05	1.02	1.00	1.02	1.13	1.10	1.09	1.11
½ Org. + ½ NPK	1.05	1.01	1.00	1.02	1.12	1.09	1.09	1.10
¼ Org. + ¾ NPK	1.04	1.01	0.99	1.01	1.12	1.09	1.08	1.10
Mean (A)	1.04	1.01	0.99		1.12	1.09	1.08	
L.S.D. at 5 %	A: N.S.	B:N.S.	AB: N.S.		A: N.S.	B:N.S.	AB: N.S.	
				Leaves magnesium %				
Control	0.47	0.45	0.45	0.46	0.52	0.50	0.50	0.51
100 % NPK	0.49	0.46	0.46	0.47	0.54	0.52	0.52	0.53
100 % Org.	0.52	0.49	0.48	0.50	0.55	0.54	0.54	0.54
¾ Org. + ¼ NPK	0.51	0.48	0.47	0.49	0.55	0.54	0.54	0.54
½ Org. + ½ NPK	0.50	0.47	0.47	0.48	0.54	0.54	0.53	0.54
¼ Org. + ¾ NPK	0.50	0.47	0.46	0.48	0.54	0.53	0.53	0.53
Mean (A)	0.50	0.47	0.47		0.54	0.53	0.53	
L.S.D. at 5 %	A: N.S.	B:N.S.	AB: N.S.		A: N.S.	B:N.S.	AB: N.S.	

The preferability of organic fertilization over mineral NPK fertilization as clearly illustrated in the present study could be explained in the light of what have been suggested by Ali (2014) who mentioned that Moringa plant can produce large quantities of leaves, but only if it receives enough organic supplement. Its leaves are rich in protein and minerals, which means that the soil needs to provide enough nitrogen and minerals to the plant. Instead of chemical fertilizer, farmyard manure or compost can provide the necessary nutrients, as well as, improve the soil structure. The author added that the best fertilization can be ensured by mixing fast decomposing residue (farmyard manure) with slow decomposing residue (straw or dry plant residue).

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الملخص العربي

تأثير فترات الري ومعاملات التسميد العضوي/المعدني على النمو الخضري والتركيب الكيماوي لنباتات المورنجا أوليفيرا

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أجريت تجربة حقلية بهدف معرفة تأثير ثلاث فترات ري وستة معاملات تسميد عضوي/معدني على النمو الخضري والتركيب الكيماوي لنباتات المورنجا. أظهرت النتائج أن جميع الصفات الخضرية (طول النبات–سمك الساق– عدد الفروع وعدد الأوراق والوزن الطازج والجاف للأوراق قد زادت تدريجياً تبعاً لتقصير فترات الري وعلى العكس من ذلك فإن الصبغات الضوئية الثلاثة (كلوروفيل أ ، ب والكاروتينويدات) وكذلك نسبة النيتروجين والفوسفور والبوتاسيوم والكالسيوم والماغنسيوم في الأوراق قد زادت تبعاً لزيادة فترات الري. بالنسبة لمعاملات التسميد العضوي/المعدني فقد نتجت أعلى قيم النموات الخضرية والقيم الكيماوية من المعاملة العضوية 100 % وتليها معاملة 75 % عضوي + 25 % معدني بالمقارنة بباقي المعاملات بما فيها معاملة الكنترول. أما بالنسبة لمعاملات التفاعل بين فترات الري ومعاملات التسميد العضوي/المعدني فقد نتجت أفضل الصفات الخضرية نتيجة ري المورنجا بأقصر فترة ري (كل 14 يوم) وتسميدها بالسماد العضوي 100 % (4 كيلوجرام سماد دواجن للنبات).