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Effect of potassium application method on growth, yield and nutrient uptake by moringa plants (*Moringa olifera* L.) irrigated with saline water.

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Abstract

Afield experiment was conducted in two successive seasons (2013 and 2014) to study the effect of potassium soil application and foliar application of some nutrients on growth, yield and nutrients uptake by Moringa plants (Moringa olifera L.) grown in a sandy soil irrigated with saline water (5.09dSm^{-1}) in the first season and (6.24 dsm^{-1}) in the second season . Different combinations of potassium soil application at 60 (K1), 120 (K2), 180(K3) and 240 (K4) kgKha-1 without or with foliar application (fol) of some nutrients i.e. 2.2, 1.8 and 2.4gL-1 for N, P and K , respectively and 250mgL-1 for Fe, Mn and Zn (fed needs 600L, ha needs 1440L). The experiment was carried out in randomized complete block design where it comprises nine treatments that were constituted of the mentioned combinations as follows control, K1, K1+fol, K2, K2+fol, K3, K3+fol, K4 and K4+fol. All treatments were applied in three doses during different growth stages of Moringa in April, May and June in both studied seasons. Results indicated that all studied treatments either with soil application of potassium only or in combinations with foliar nutrition surpassed significantly the control treatment concerning all the studied parameters of growth and yield and nutrients uptake either by leaves or seeds of Moringa plant in both the studied seasons. Gradual significant increases were observed in all the studied parameters of Moringa with the gradual increases in the rates of soil application of potassium in both studied seasons. The integration of potassium soil application with some nutrients foliar application surpassed significantly the potassium soil application only regarding all the studied Moringa growth and yield parameters as well nutrients uptake by leaves and seeds of Moringa plants in both studied seasons. The most effective significant treatment was K4+fol (240kgKha-1+folir application with 250mgL-1 of Fe, Mn and Zn and 2.2, 1.8 and 2.4g L-1) for N, P and K, respectively, in both the studied seasons.

Key word: Soil fertilizer K, foliar nutrients,salinity, growth, yield parameters and nutrients uptake by Moringa plant

Introduction

Salinity is a major problem that negatively impacts agricultural activities in newly reclaimed areas of Egypt, especially the soils that were irrigated with saline water such as that of the current study i.e.soil of El Sheikh Zawed, North Sinai, Egypt. Moringa (*Moringa oleifera*) is a new plant and has ability to grow and produce leaves and seeds under condition of salinity and water stress. So, Moringa is a more suitable plant to live and produce under conditions of desert soils in Egypt.

Regarded to nutrients composition of moringa plant, **Busani et al.(2011)** reported that the objective of the study was to assess the nutritional value of moringa leaves of the South African ecotype, the dried leaves of Moringa plant had the following mineral contents: calcium (3.65%), phoshorus (0.3%), magnesium (0.5%), potassium (1.5%), sodium (0.16%), sulphur (0.63%), zinc (13.03 mg kg^{-1}), copper (8.25%), manganese (86.8 mg kg^{-1}), iron (490 mg kg^{-1}) and selenium (363 mg kg^{-1}). **Shahzad et al.(2015)** found that the percentages of nitrogen, phosphorous, potassium, calcium content and ascorbate were 6.11, 3.4, 9.14, 2.53 % and 89.73 µg/g , respectively in dried leaves when moringa crop was harvested at 30 d cutting interval at broad spacing under conditions of nitrogen applied at 90 kg ha^{-1} as basal dose using urea as a source.

Concerning to mineral fertilizers and organic matter effect on yield parameters of moringa plants**, Makinde (2013)** stated that the highest fertilizer rate (120 kg N:P:K 15:15:15 ha^{-1}) produced the highest quantity of protein (19.01%) and other yield parameters of moringa plants, when compared with other rates of fertilizers. **Larwanou *et al*. (2014)** reported that the mineral fertilization and watering regimes are highly correlated to growth, development parameters (height, diameter and dry biomasses) and nutrients uptake for moringa. **Dania *et al*. (2014)** reported that the application of poultry manure increased the yield components (height, number of leaves, and stem girth) and growth and nutrient content of Moringa compared to the application of NPK and organo-mineral fertilizer.

Foliar application of macro and micronutrients has been reported as an effective method to increase salt tolerance in plants and have been suggested to ameliorate the adverse effect of salt stress **(Hamayun *et al*. 2011). Khalid and Shedeed (2015)** reported that the combination of NPK soil application with foliar nutrition was the most effective treatment that resulted in a positive increase in vegetative growth. **Yildirim *et al*. (2007)** reported that the greatest yield values were obtained from 1.0% rate of urea as foliar application, while the optimum or economy yields of broccoli plants were obtained by foliar application urea at 0.9% rate. **Mannan (2014)** stated that the foliar spray of NPK at the rate of 100 mg L^{-1} of water (1440L ha^{-1}) enhanced the growth and yield of the soybean as well as protein content in soybean seed, at the two growth stages compared to soil fertilization. **Soliman et al.,(2015)** reported that the moringa plants sprayed with Hoagland-containing ZnO and Fe_3O_4 and NP at rates (30, 60 and 90 mg L^{-1}) showed an enhancement in growth parameters either under normal or saline conditions when compared to control. Also, spraying plants with Hoagland-containing ZnO and Fe_3O_4 NP at highest rate (90 mg/L) resulted in significant reduction in Na+ and Cl- and increases in N, P, K, Mg, Mn, Fe, Zn, total chlorophyll, carotenoids, proline, carbohydrates, crude protein levels, antioxidant non-enzymes and enzymes when compared to control the objective of this study was to study the effect of potassium soil application and some nutrients spraying on growth, yield and nutrients uptake by moringa shrubs (Moringa olifera L.) under irrigation with saline water.

Materials and Methods

Plant materials and treatments:

The present study was carried out in two successive seasons i.e. 2013 and 2014 at El Sheikh Zoweid Research Station of the Desert Research Center (DRC), North Sinai, Egypt, at the indices of 31 14' 9.8" N, 34 6' 54.4" E, on one year old moringa plants (*Moringa Oliefera* L) grown on a sandy soil under drip irrigation system. Some physical and chemical properties of the investigated soil are shown in Table 1 on the other hand chemical properties of the water used for irrigation are presented in table 2.

Table 1. The soil physical and chemical properties

Properties	**Soil depth(cm)**	
	0 – 30	**30 – 60**
	Particle size distribution	
Sand (%)	90.51	91.30
Silt (%)	4.64	4.94
Clay (%)	4.85	3.76
Soil texture	Sand	Sand
EC (dSm^{-1})	0.73	0.86
pH	7.06	7.18
O.M g kg^{-1}	8.50	7.30
Ca CO3 g kg^{-1}	24.90	23.70
	Soluble anions (mmolc L-1)	
HCO_3^-	3.00	3.54
Cl^-	2.78	3.28
$SO4^{2-}$	1.52	1.79
	Soluble cations (mmolc L-1)	
Na^+	2.32	2.74
K^+	0.22	0.26
$Ca2^+$	2.75	3.25
$Mg2^+$	2.03	2.40
Available N (mg kg^{-1})	18.60	12.7
Available P(mg kg^{-1})	1.92	1.25
Available K(mg kg^{-1})	27.00	21.00
Available Fe(mg kg^{-1})	5.52	3.87
Available Mn(mg kg^{-1})	2.18	1.94
Available Zn(mg kg^{-1})	0.97	0.68
Available Cu(mg kg^{-1})	0.28	0.22

pH and EC: were measured in the saturated soil paste extract and SO_4^{2-}: was calculated by the difference between the sum of cations and anions .

Table 2. Some properties (mmolc L^{-1}) of the water used for irrigation

Parameter	first season	second season
EC (dSm^{-1})	5.09	6.24
pH	8.30	8.04
CO_3^{2-}	0.67	0.82
HCO_3^-	2.43	2.04
Cl^-	37.14	36.68
SO_4^{2-}	15.10	22.80
Na^+	30.87	37.73
K^+	15.22	13.36
Ca^{2+}	0.21	0.14
Mg^{2+}	10.79	10.59

Experimental moringa shrubs were chosen in similar healthy and vigor and received the same horticultural practices. The moringa plants were cultivated at 1.5×1.5m spacing area. Potassium soil application was applied at four rates i.e. 60, 120, 180 and 240 kg K2O ha-1 as potassium sulfate (50% K2O) in three doses during different growth stages of moringa in April, May and June in both seasons of study. The selected shrubs were sprayed with some nutrients in the same times of potassium soil application in three doses as shown in Table 3.

Table 3. Types and quantity of some nutrients that were applied as foliar spray at different doses during different growth stages of moringa in both studied seasons**.**

Foliar fertilizers applied at two rates non-foliar and foliar/1440Lwater ha^{-1}						
Nutrients	**N**	**P**	**K**	**Fe**	**Mn**	**Zn**
Dose		**gL^{-1}**			**mgL^{-1}**	
$Dose_1$	**0.931**	**0.435**	**0.625**	**50**	**50**	**50**
$Dose_2$	**0.760**	**0.580**	**0.799**	**100**	**100**	**100**
$Dose_3$	**0.508**	**0.797**	**1.007**	**100**	**100**	**100**
Total nearly	**2.2**	**1.8**	**2.4**	**250**	**250**	**250**

Moringa shrubs were arranged in randomized complete block design (RCBD) and the following treatments were done with three replicates (3shrubs/replicate) for each treatment in nine different combinations as follows:

1. Control (with neither K soil application nor nutrient spraying).
2. Soil application of K at a rate of 60 $kgKha^{-1}$ (K_1).
3. Soil application of K at a rate of 120 $kgKha^{-1}$ (K_2).
4. Soil application of K at a rate of 180 $kgKha^{-1}$ (K_3).
5. Soil application of K at a rate of 240 $kgKha^{-1}$ (K_4).
6. Soil application of K at a rate of 60 $kgKha^{-1}$ + foliar nutrients (K_1+fol).
7. Soil application of K at a rate of 120 $kgKha^{-1}$ +foliar nutrients (K_2+fol).
8. Soil application of K at a rate of 180 $kgKha^{-1}$ +foliar nutrients (K_3+fol).
9. Soil application of K at a rate of 240 $kgKha^{-1}$ +foliar nutrients (K_4+fol).

Growth parameters such as shrub canopy, shrub length (m), trunk collar, number of branches/tree, number of leaves /branch, pod length (cm) and number of pods/shrub were recorded for all treatments in both seasons.

Yield parameters of Moringa such as leaves yield (g)/shrub, fresh pods yield (kg) /shrub, seeds yield (kg)/shrub, leaves yield $Mgha^{-1}$, fresh Pods yield $Mgha^{-1}$, seeds yield $Mgha^{-1}$ and oil seed yield $kgha^{-1}$ were recorded for all treatments in both seasons.

Soil analyses were done according to **Page *et al.* (1984) and Klute (1986**). Plant samples were analyzed for macro and micronutrients according to **Cottenie *et al* (1982).** The oil seeds were extracted as described by **Stock fleth and Brunner (1999)**.

Data were analyzed by analysis of variance (ANOVA), and means were compared using LSD test at $p < 0.05$ to determine the significance of differences between the conducted treatments (**Gomez and Gomez, 19**84)

Results and Discussion

1. Effect of potassium soil application and some nutrients spraying on moringa growth parameters

As shown **Table 3** it can be noticed that all the studied treatments whether soil application of potassium only or combined with foliar nutrition application surpassed significantly the control treatment concerning all growth parameters i.e shrub canopy, shrub length (m), trunk collar, number of branches/tree, number of leaves /branch, pod length (cm) and number of pods/shrub in both the growth seasons. Moreover significant increases occurred in these growth parameters due to increasing rates of applied potassium in both the study seasons. The integration of potassium soil application with some nutrients foliar application surpassed significantly the soil applications of potassium regarding all the studied moringa growth parameters in both the studied seasons. The most effective significant treatment was K_4+fol (240kgKha-1+foliar application with 250mgL-1 of Fe, Mn and Zn and 2.2, 1.8 and 2.4gL^{-1} for N, P and K respectively (ha needs 1440L), which achieved highest increases of growth, yield parameters and nutrients uptake by leaves and seeds of Moringa plant in both studied seasons.

Table 3. Effect of potassium soil application and some nutrients foliar application on growth parameters of moringa plants during the two successive seasons.

Treatment	Shrub canopy (m)	Shrub length (m)	Trunk collar (cm)	No. of branch /Shrub	No. of leaves /branch	Pod length (cm)	No. of Pods / shrub
				Season1			
Control	0.68	1.34	2.7	7.1	12.4	13.7	23.7
K1	1.31	2.42	4.85	18.8	39.5	22.43	39.6
K2	1.35	2.47	4.91	20.83	41.3	26.38	47.6
K3	1.39	2.51	4.97	21.73	43.4	29.63	55.4
K4	1.43	2.55	5.01	23.13	46	33.65	61.7
K1+fol	1.49	2.67	5.48	21.98	49.5	28	47.7
K2+fol	1.53	2.71	5.54	23.4	50.6	31.28	56.6
K3+fol	1.57	2.74	5.6	24.75	52.6	34.7	65.6
K4+fol	1.61	2.78	5.65	26.18	55.2	37.88	76.2
$LSD_{0.05}$	0.0127	0.014	0.0339	0.1951	0.4391	0.6661	3.2506
				Season2			
Control	0.6	1.14	2.35	6	10.8	13	22.8
K1	1.39	2.53	5.47	19.93	42.9	22.83	43.7
K2	1.43	2.59	5.55	22.25	45	26.88	52.8
K3	1.47	2.64	5.62	23.33	47.5	30.18	61.7
K4	1.5	2.67	5.66	24.78	50.2	34.3	68.6
K1+fol	1.57	2.79	6.19	23.43	54	28.55	52.9
K2+fol	1.6	2.84	6.26	25.05	55.3	31.88	62.9
K3+fol	1.65	2.89	6.34	26.65	57.6	35.4	73.2
K4+fol	1.69	2.92	6.39	28.08	60.3	38.63	84.9
$LSD_{0.05}$	0.0139	0.0223	0.042	0.2257	0.5103	0.2673	0.5995

The average increases in the different studied moringa growth parameters due to the application of K4+fol treatment compared with K1 (60kgKha-1 without foliar nutrition) treatment were about 22, 15, 17, 40, 40, 69 and 93% for, shrub canopy (m), shrub length (m), trunk collar, No. of branches /shrub, No. of leaves /branch, pod length (cm) and No. of pods/ shrub, respectively (Fig.1).

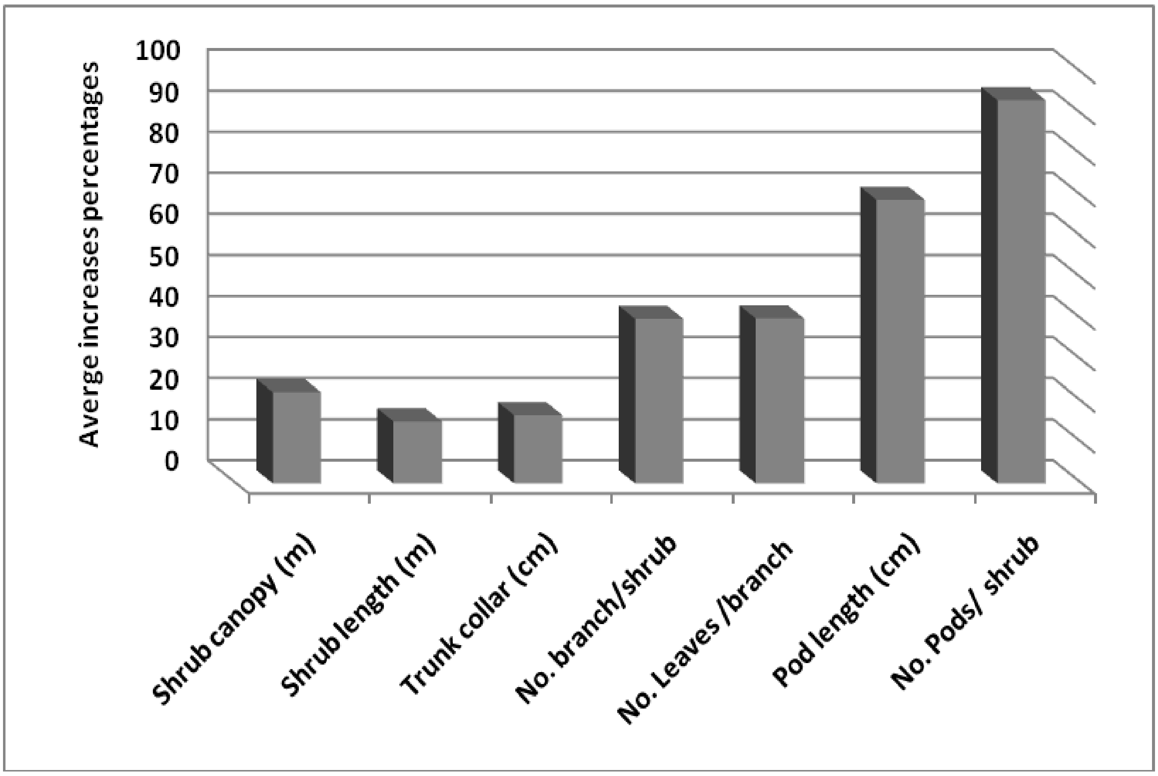

Fig. 1: The average increases in different studied moringa growth parameters due to the application of K4+fol treatment compared with K1 (average of the two successive seasons)

Fig. 1 reveals that the growth parameters of moringa plants can be arranged according to the increase application of K4+fol treatment compared with K1 treatment in the following descending order: No of pods/ shrub > pod length (cm) > No of leaves /branch > No of branches/shrub > trunk collar > shrub length (m) > shrub canopy (m).

These findings agree with those obtained by **Makinde (2013)** and **Larwanou *et al*. (2014)** who found that the highest soil fertilizer rate produced the highest quantity of yield parameters of moringa plants, when compared with lower rates of fertilizers. **Soliman et al.,(2015)** who found that the moringa plants sprayed with high rate of Hoagland-containing ZnO and Fe3O4 and NP at rates (90 mg/L) showed an enhancement in moringa growth. **Mannan (2014)** and **Shedeed (2015)** who found that the combination between NPK soil application and foliar nutrition were increased vegetative growth and nutrients uptake by moringa plant. **Wang *et al*., (2013)** who found that The availability of K and its effects on plant growth and plant metabolism are discussed. The physiological and molecular mechanisms of K function in plant stress resistance are reviewed. and evaluation the potential for improving plant stress resistance by modifying K fertilizer inputs.

2. Effect of potassium soil application and some nutrients spraying on moringa yield parameters

Data in **Table 4** show that all the studied treatments whether the soil application of potassium alone or in combination with foliar nutrition surpassed significantly the control treatment in the all yield parameters i.e. leaves yield in kg/shrub, fresh pods yield in kg/shrub, seeds yield in kg/shrub, leaves yield in $Mgha^{-1}$, fresh pods yield in $Mgha^{-1}$, seeds yield in $Mgha^{-1}$ and oil seed yield in $kgha^{-1}$ in both the studied seasons. Significant increases in the different yield parameters were noticed with increasing rate of potassium soil application in both the study seasons. The integration of potassium soil application with some nutrients foliar application surpassed significantly the potassium soil application alone in all the studied moringa yield parameters in both seasons of study. The most effective significant treatment was K_4+fol in both the studied seasons.

The average increases in the different studied moringa growth parameters due to the application of K4+fol treatment increased when compared with K_1 ($60kgKha^{-1}$ without foliar nutrition) treatment were 78, 70, 222, 78, 70, 218 and 438% for leaves yield in kg/shrub, fresh pods yield in kg/shrub, seeds yield in kg/shrub, leaves yield in $Mgha^{-1}$, fresh pods yield in $Mgha^{-1}$, seeds yield in $Mgha^{-1}$ and oil seed yield in $kgha^{-1}$ respectively (Fig.2).

Table 4. Effect of potassium soil application and some nutrients foliar application on yield parameters of moringa plants during the two successive seasons.

Treatment	Leaves yield in kg/shrub	Fresh Pods yield in kg/shrub	Seeds yield in kg/shrub	Leaves yield in $Mgha^{-1}$	Fresh Pods yield in $Mgha^{-1}$	Seeds yield in $Mgha^{-1}$	Oil seed yield in $kgha^{-1}$
				Season1			
Control	0.14	4.18	0.03	0.62	18.6	0.167	26
K1	0.95	7.08	0.095	4.22	31.4	0.436	121
K2	1.10	8.5	0.135	4.9	37.8	0.607	202
K3	1.21	9.9	0.185	5.39	44	0.816	312
K4	1.37	11.02	0.225	6.09	49	1.019	417
K1+fol	1.31	7.76	0.125	5.81	34.5	0.555	193
K2+fol	1.44	8.91	0.175	6.41	39.6	0.769	307
K3+fol	1.56	10.34	0.245	6.92	45.9	1.078	474
K4+fol	1.68	12	0.305	7.48	53.3	1.357	643
$LSD_{0.05}$	0.018	0.944	0.0202	0.0721	0.36	0.013	6.621
				Season2			
Control	0.10	3.9	0.03	0.19	17.9	0.143	21
K1	1.34	8.6	0.113	2.5	38.3	0.5	143
K2	1.57	10.35	0.16	2.93	46.1	0.702	240
K3	1.74	12.08	0.215	3.24	53.7	0.976	376
K4	1.96	13.45	0.273	3.65	59.8	1.209	502
K1+fol	1.85	9.45	0.15	3.46	42	0.65	228
K2+fol	2.06	10.85	0.205	3.83	48.3	0.912	369
K3+fol	2.23	12.63	0.288	4.17	56	1.285	571
K4+fol	2.40	14.63	0.365	4.49	65.1	1.618	776
$LSD_{0.05}$	0.0251	0.1109	0.0058	0.0463	0.483	0.016	8.033

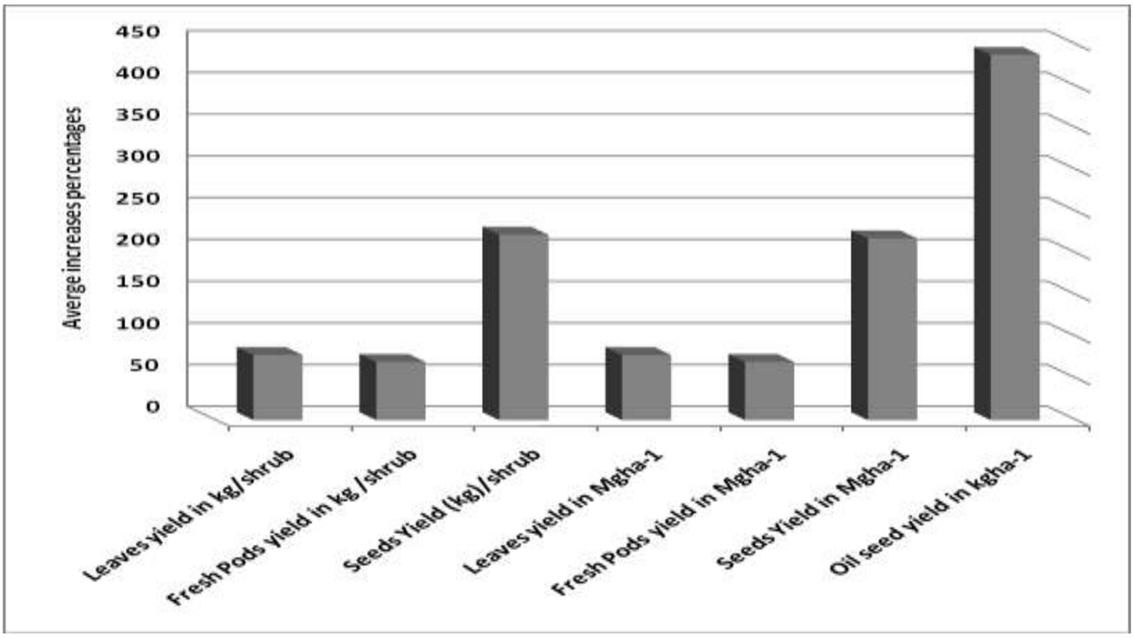

Fig. 2: The average increases in different studied moringa yeld parameters due to the application of K4+fol treatment compared with K1 (average two successive seasons)

The previous data From fig .2 it can be concluded that the increase percentages in the yield parameters of Moringa plants due to the application of K_4+fol treatment compared with K_1 treatment can be arranged in the following descending order: oil seed yield in $kgha^{-1}$ > seeds yield in $Mgha^{-1}$ > seeds yield in kg/shrub > leaves yield in kg/shrub = leaves yield in $Mgha^{-1}$ > fresh pods yield in kg/shrub = fresh pods yield in $Mgha^{-1}$.

It could be concluded that contents of available nutrients in the sandy soil are not sufficient to fulfill the nutritive requirements during different stages of moringa growth. The balanced fertilization achieved highest yield components and nutrients contents of moringa plant, so it is always superior and most effective treatment when compared with other treatments in the studied soil. All treatments were significantly better than the control treatment in all growth and yield parameters of Moringa. The foliar application of macro and micronutrients in present the soil application of NPK fertilizers were higher increases of yield parameters and nutrients content in moringa plant than other treatments, these fact assure that the nutrients were nearly to sufficiently levels of Moringa requirements during different stages of Moringa growth. These findings agree with those obtained by **Yildirim *et al.* (2007)** who found that foliar urea at rate 0.9% was economic yield when compared with rate 1%. **Khalid and Shedeed (2015)** who found that the combination of NPK soil application with foliar nutrition was a positive increase in vegetative growth.

3. Effect of potassium soil application and some nutrients spraying on macronutrients uptake by moringa leaves and seeds:

Results presented in Table 5 indicate that all the studied treatments whether soil application of potassium only or in combination with foliar nutrition surpassed significantly the control treatment regarding macronutrients uptake by moringa leaves and seeds in both the studied seasons.

Table 5. Effect of potassium soil application and some nutrients foliar application on macronutrients uptake by moringa plants during the two successive seasons.

Treatment	N $kgha^{-1}$		P $kgha^{-1}$		K $kgha^{-1}$	
	Leaves	Seeds	Leaves	Seeds	Leaves	Seeds
	Season1					
Control	9.04	1.64	0.14	0.05	0.74	1.36
K1	98.53	7.40	2.45	0.29	11.57	5.81
K2	116.14	10.54	3.31	0.50	21.85	9.33
K3	129.47	14.45	4.17	0.74	35.32	14.30
K4	148.75	18.37	5.31	1.05	52.60	20.18
K1+fol	148.51	10.42	4.43	0.60	24.87	8.43
K2+fol	164.70	14.71	6.55	1.02	40.08	13.35
K3+fol	180.17	20.97	9.28	1.71	57.72	21.09
K4+fol	197.78	26.92	11.02	2.40	74.28	29.56
LSD0.05	1.912	0.263	0.121	0.026	0.808	0.302
	Season2					
Control	7.14	1.12	0.07	0.02	0.57	0.95
K1	152.32	10.21	4.14	0.38	19.47	7.85
K2	180.64	14.61	5.40	0.64	38.29	12.33
K3	202.78	20.71	6.71	1.00	57.38	18.92
K4	233.24	26.18	8.78	1.43	80.16	25.51
K1+fol	225.86	14.90	6.90	0.81	49.62	11.47
K2+fol	253.47	21.32	10.16	1.36	71.14	17.95
K3+fol	280.13	30.68	14.47	2.24	89.65	27.66
K4+fol	307.26	39.32	17.92	3.26	115.12	37.70
LSD0.05	3.026	0.396	0.186	0.035	1.236	0.384

Significant increases in macronutrients took place due to increasing rates of potassium soil application in both study seasons. The integration of potassium soil application with some nutrients foliar application surpassed significantly the potassium soil application only regarding all studied macronutrients uptake by leaves and seeds of moringa in both the studied seasons. The most effective significant treatment was K4+fol in both the studied seasons.

The average percentage increases in the different studied macronutrients uptake by moringa leaves and seeds due to the application of K_4+fol treatment compared with K_1 treatment were 101, 339 and 510% by leaves and 276, 745, and 392% by seeds for N, P and K, respectively (Fig.3).

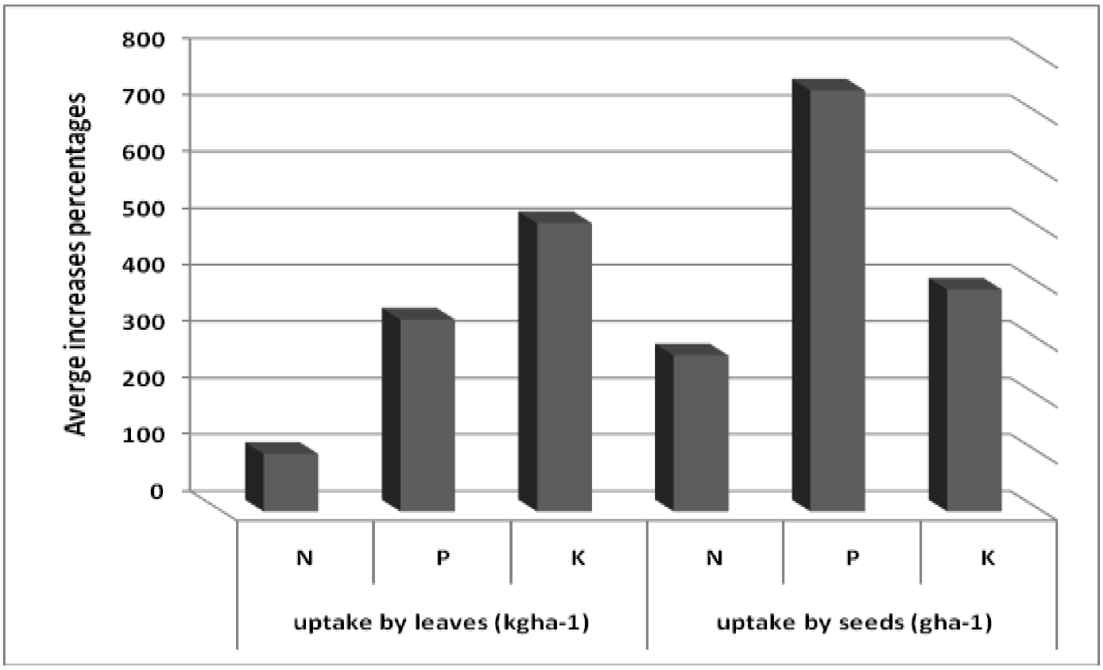

Fig. 3: The average increases in macronutrients uptake by leaves and seeds of moringa plants due to the application of K4+fol treatment compared with K1(average of the two successive seasons)

According to the application of K_4+fol treatment compared with K_1 treatment (Fig. 3) it can be concluded that the increase percentage in uptake values of the studied macronutrients take up by leaves of moringa plant followed the descending order: K uptake > P uptake > N uptake, whereas, macronutrients by seeds of moringa plant the following descending order was attained for the uptake values of: P uptake > K uptake > N uptake.

The obtained results agree with those obtained by **Makinde (2013)** who found that the highest fertilizer rate (120 kg N:P:K 15:15:15/ha) produced protein (19.01%). **Larwanou *et al*. (2014)** who found that the mineral fertilization and watering regimes was increased nutrients uptake by moringa. **Dania *et al*. (2014)** who found that the application of poultry manure increased the nutrient content of Moringa compared to the application of NPK and organo-mineral fertilizer.

4. Effect of potassium soil application and some micronutrients spraying on nutrients uptake by moringa leaves and seeds:

Results presented in **Table 6** reveal that application of potassium as well as its combination with foliar nutrition surpassed significantly the control treatment regarding micronutrients uptake by moringa leaves and seeds in both the studied seasons. Significant increases in micronutrients occurred due to increasing rates of potassium soil application in both study seasons. The effect of integrating potassium soil application with some nutrients foliar application surpassed significantly the effect of solely applied potassium regarding all studied micronutrients (Fe, Mn, Zn, Cu) uptake by leaves and seeds of moringa plant in both the studied seasons. The most effective significant treatment was K4+fol in both the studied seasons.

The average increases in the studied micronutrients uptake by Moringa leaves and seeds due to the application of K_4+fol treatment compared with K_1(60kgKha^{-1} without foliar nutrition) treatment were about 219, 297, 416 and 187% by leaves and 461, 584, 572, and 442% by seeds for Fe, Mn, Zn and Cu, respectively (Fig.4).

According to the increase percentages in the uptake values the studied micro nutritive elements that occurred due to K_4+fol treatment as compared with K_1 treatment the following descending order was achieved: Zn uptake > Mn uptake > Fe uptake > Cu uptake. Although the arrangement of micronutrients uptake by seeds took the same trend of that characterized their uptake by leaves, the average increase percentages of micronutrients uptake by seeds were more than these recorded for leaves.

The above results agree with **Njogu *et al*. (2014), Fahad *et al*.,(2014), Khalid and Shedeed (2015)** who found that the combination between NPK soil application and foliar nutrition were increased vegetative growth and nutrients uptake by moringa plant. **Soliman et al.,(2015)** who found that the foliar Hoagland-containing ZnO and Fe_3O_4 and NP at rates (90 mg/L) was significant reduction in Na+ and Cl- and increases in N, P, K, Mg, Mn, Fe, Zn in moringa plant. **FAO and IFA (2000), Makinde (2013), Dania *et al*. (2014)** and **Attia *et al*. (2014)** who found that NPK soil application produced the highest quantity of protein and other yield parameters of moringa plants.

Table 6. Effect of potassium soil application and some nutrients foliar application on micronutrients uptake by moringa plants during the two successive seasons.

Treatment	Fe gha^{-1}		Mn gha^{-1}		Zn gha^{-1}		Cu gha^{-1}	
	Leaves	Seeds	Leaves	Seeds	Leaves	Seeds	Leaves	Seeds
				Season1				
Control	98	31	43	19	24	10	6	2.0
K1	1009	112	474	52	262	29	64	7.1
K2	1304	171	576	76	345	45	85	11.0
K3	1557	250	743	121	462	74	112	18.0
K4	1840	336	926	169	600	109	142	25.8
K1+fol	1871	195	1038	107	695	71	99	10.2
K2+fol	2199	290	1266	167	871	114	123	16.3
K3+fol	2487	445	1540	257	1073	179	150	26.8
K4+fol	2856	602	1821	350	1292	252	182	38.1
LSD0.05	28.42	6.160	19.739	4.223	14.262	2.644	1.799	0.395
				Season2				
Control	76	21	36	12	19	7	5	1.4
K1	1485	136	704	64	388	38	110	10.5
K2	1966	214	900	98	543	64	154	18.0
K3	2416	336	1204	167	724	102	191	28.8
K4	3051	459	1507	226	947	145	233	39.3
K1+fol	3194	264	1680	138	1092	90	160	14.4
K2+fol	3803	395	2040	212	1397	143	211	24.3
K3+fol	4422	593	2430	326	1702	228	262	40.0
K4+fol	5110	790	2858	443	2063	319	317	57.3
LSD0.05	53.34	8.148	30.412	4.450	22.322	3.360	3.186	0.601

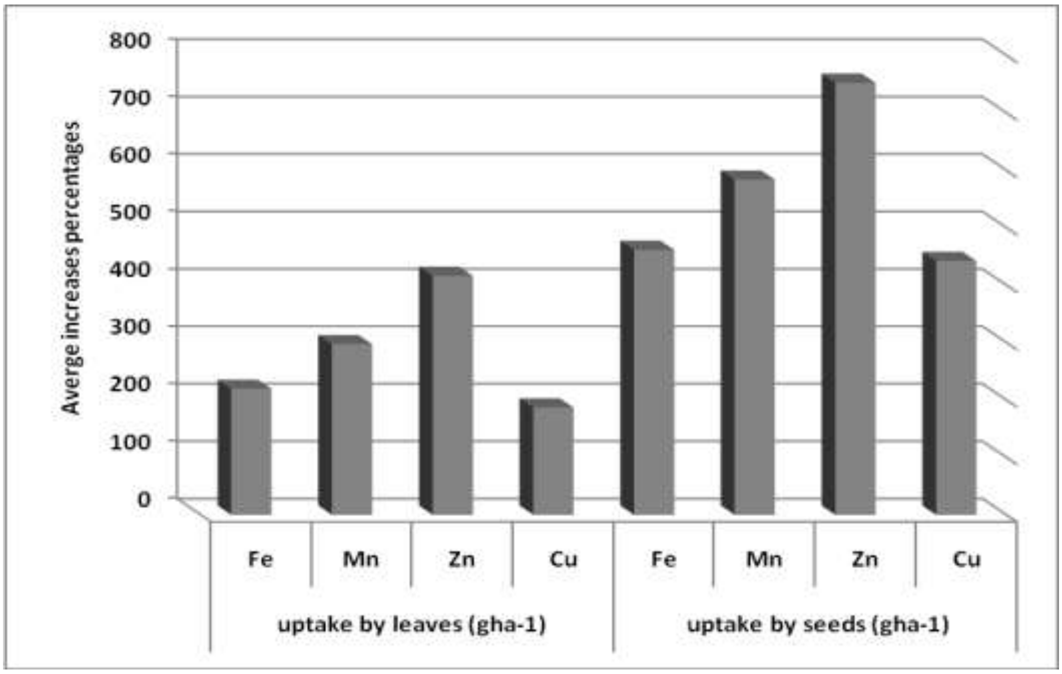

Fig. 4: The average increases in micronutrients uptake by leaves and seeds of moringa due to the application of K4+fol treatment compared with K1 (average two successive seasons).

In conclusion, in the study soils, soil application of K and foliar nutrients increased nutrients uptake and yield parameters of moringa plant. Moreover, gradual significant increases were observed in all the studied parameters of Moringa with the gradual increases in the rates of soil application of K in both studied seasons. The integration of K soil application with some nutrients foliar application surpassed significantly the K soil application only regarding all the studied Moringa growth and yield parameters as well nutrients uptake by leaves and seeds of Moringa plants in both studied seasons. The most effective treatment was K_4 (240kgK/ha) + foliar nutrients which achieved 5.99 $Mgha^{-1}$ leaves and 710 $kgha^{-1}$oil seed as average in both studied seasons. the increase percentage in uptake values of the studied macronutrients take up by leaves of moringa plant followed the descending order: K uptake > P uptake > N uptake, whereas, macronutrients by seeds of moringa plant the following descending order was attained for the uptake values of: P uptake > K uptake > N uptake, while in micronutrients case; Zn uptake > Mn uptake > Fe uptake > Cu uptake. Although the arrangement of micronutrients uptake by seeds took the same trend of that characterized their uptake by leaves.

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تأثير طريقة إضافة البوتاسيوم علي نمو ومحصول وامتصاص المغذيات بواسطة نباتات المورينجا المروية بمياة مالحة

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أجريت تجربة حقلية في موسمين متتاليين (2013 و 2014) لدراسة تأثير الإضافة الأرضية للبوتاسيوم والرش الورقى لبعض المغذيات على النمو والمحصول والممتص من المغذيات لنباتات المورينجا التي تزرع في أرض رملية تروى مع المياه المالحة ($5.09 dSm^{-1}$) موسم أول و ($6.24\ dSm^{-1}$) موسم ثاني. تم عمل توليفات مختلفة من الإضافة الأرضية للبوتاسيوم بمعدلات [60 (K1) ، 120 (K2) ، 180 (K3) ، 240 (K4)كجم بوتاسيوم/هكتار] بدون أو مع الإضافة الورقية (fol) لبعض المغذيات (250جرام/لتر من كل من الحديد والمنجنيز والزنك) ، 2.2 ، 1.8 ، 2.4جم/لتر لكل من N، P ، K على الترتيب (1440L/ هكتار). وقد نفذت التجربة في بنصميم القطاعات كاملة العشوائية حيث تضم تسعة معاملات تم تكوينها من التوليفات المذكورة وهى كالتالى (control, K, K1+fol, K2, K2+fol, K3, K3+fol, K4 and K4+fol). تم إضافة كافة المعاملات في ثلاث جرعات خلال مراحل النمو المختلفة لنبات المورينجا في أبريل ومايو ويونيو على التوالي، في كلا موسمى الدراسة.

وأشارت النتائج إلى أن جميع المعاملات تحت الدراسة سواء إضافة البوتاسيوم الأرضية فقط أو مع الرش الورقي بالمغذيات تفوق معنويا على معاملة المقارنة فى كل مقاييس النمو والإنتاجية والممتص من العناصر الغذائية سواء فى أوراق أو بذور نباتات المورينجا فى كلا موسمى الدراسة. كذلك لوحظت زيادات تدريجية معنوية في القياسات تحت الدراسة مع الزيادة التدريجية لمعدلات الإضافة الأرضية للبوتاسيوم فى كلا موسمى الدراسة.

وفيما يتعلق بتأثير التكامل بين الإضافة الأرضية للبوتاسيوم والورقية لبعض المغذيات فقد أدى لزيادة معنوية فى كافة مقاييس النمو والإنتاجية وكذلك الممتص من العناصر الصغرى والكبرى بأوراق وبذور نبات المورينجا ، وكانت المعاملة الأكثر فاعلية معنوية هى (K4+fol) أى الإضافة الأرضية للبوتاسيوم عند معدل 240كجم/هكتار مع الرش الورقى لبعض المغذيات بتركيزات 250ملجم/لتر من كل من الحديد وامنجينز والزنك ، 2.2 ، 1.8 ، 2.4جم/لتر من كل من النيتروجين والفوسفور والوتاسيوم على الترتيب.