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Response of Carrot (*Daucus carota* L.) to Foliar Application of Potassium Fertilizers and some Soil Amendments under Clay Soil Conditions

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ABSTRACT

To study the response of carrot crop (*Daucus carota* L.) to foliar application of different potassium fertilizers and some soil amendments i.e., magnetite iron and humic substances (granules or powder) under clay soil conditions, two field experiments were conducted during winter seasons of 2014 and 2015 at the Horticulture Experimental Station of Agriculture Ministry, El-Baramon Experimental Farm, Dakahlia Government, Egypt. The obtained results revealed that humic substances granules or magnetic iron caused marked increases on vegetative growth, yield and NPK uptake in both shoots and roots of carrot plants. Potassium foliar application caused significant increasing on previously mentioned characters as well as carbohydrate and carotenoids content in roots. In addition, potassium foliar application caused significant increasing on previously mentioned characters, which showed a progressive increase in its content with application KNO_3 compared with other sources of potassium. There were statistically significant increases in plant growth, yield, carotenoids, carbohydrate and NPK contents of carrot due to humic substances granules treatment especially under application of potassium nitrate. Finally, the foliar application of potassium nitrate integrated with humic granules or magnetic iron was the best combination and it is recommended for increasing productivity and improving root quality of carrot (cv. Chantenay) under clay soil conditions.

Keywords: humic substances (granules and powder), magnetic iron, K-foliar application, carrot plant.

INTRODUCTION

Optimum economical yield is needed appropriate quantities of nutrients which supply to the crop. Nutrients uptake within plants affected by soil properties such as texture, soil reaction (pH), cation exchangeable capacity and capability of soil to hold the water. In this respect, soil amendments *i.e.* humic acid and magnetic iron improve these characterizes (Canellas and Olivares, 2014). Also, humic acid stimulates plant growth by acting on mechanisms involved cell respiration, photosynthesis, enzyme activities, protein synthesis and nutrient uptake (Nardi *et al.,* 2002; Zhang and Ervin, 2004). In addition, humic substances have extensive a soil conditioner, fertilizer and soil supplement (Nardi *et al.,* 2002; Albayrak and Camas, 2005; Selim *et al.,* 2009 and Selim and Mosa, 2012).

The application of humic substances has been reported to improve plant growth and chemical composition and reflected in higher crop yields and quality on watermelon (Salman *et al.,* 2005), potato (Selim *et al.,* 2009), broccoli plant (Selim and Mosa, 2012) and squash (El-Masry *et al.,* 2014). Moreover, El-Shabrawy *et al.*, (2010) found that the soil application of humic acid gave the highest values of growth, yield and nutritional status of cucumber plants.

At last years, the use of humic acid within farmers as natural promoting substances has increased in due to its specific properties of being environmentally friendly and easily degradable. Numerous researchers concluded that enhancing effect of humic acid on growth, nutrients uptake and yield of vegetable plants. Improving soil properties can be induced by using magnetite (magnetic iron) which is one of the most useful factors affected on plant growth; magnetic iron has a black or brownish-red color, it is a natural row rock that has very high iron content (Mansour, 2007). It has been reviewed that the positive effect of magnetic treatment may be attributed to paramagnetic properties of some atoms in plant cells and some pigments such as chloroplasts, magnetic properties of molecules determine their ability to attract and then change the energy of a magnetic field in other types of energy and to transfer this energy to other structures in plant cells, thus activating them (Aladjadjiyan, 2010). Magnetic field plays an important role in cation uptake capacity and has a positive effect on immobile plant nutrient uptake, such as Ca and Mg (Esitken and Turan, 2004).

Generally, potassium plays some unique and useful roles that catalyze the metabolic activities at the cellular and organ levels which results in an elevation in energy conversion, carbohydrate assimilation (Johanston, 1997 and Krauss, 2003 and Abdalla, *et al.,* 2009). Moreover, potassium can also exert a favorable effect on root development.

Carrot (*Daucus carota* L.) is a root vegetable, inherent to southwestern Asia and Europe. Generally, the taproot is the most eaten part of the plant, although the shoot is seldom eaten in some countries. Further, carrot plants (*Daucus carota*) are considered a good source of vitamin B6 (11% DV) and vitamin K (13% DV), but otherwise have modest content of other essential nutrients (Iorizzo *et al.,* 2013).

Considering the above facts, the present study was undertaken to investigate the effect of some soil amendments such as magnetic iron and humic substances as well as potassium sources on growth, yield and NPK content as well as the quality of carrot under clayey soil conditions.

MATERIALS AND METHODS

Location of the experiment:

Tow field experiments were laid out during successive growing seasons of 2014 and 2015 at the Horticulture Experimental Station of Agriculture Ministry at El-Baramon Experimental Farm, Dakahlia Government, Egypt, to study the combined effect of magnetite and humic substances i.e., granules or powder as soil amendments integrated with different sources of potassium as a foliar application on quality and yield of carrot (*Daucus carota* L.) cv. Chantenay.

Soil sampling:

The selected soil has a clayey texture soil. The representative samples were taken before sowing in the two seasons for physico-chemical analysis. The soil pH value was 8.21, EC was $0.9 dSm^{-1}$ and 1.33 % organic matter. Soil available N, P and K contents were 43.4, 4.48 and 181 $mg\ kg^{-1}$ soil for the first season, and 42.1, 4.41 and

177 mg kg^{-1} for the second season, respectively. Soil analysis was done using the standard method described by Jackson (1967).

Experimental design and treatments:

The experiment was laid in split-plot design with three replicates; main plots were occupied with soil amendments sources; magnetite 200 kg fed^{-1} and 20 kg fed^{-1} of humic substances granules and powder compared with untreated. While, the sub-plots were assigned with three sources of potassium fertilizers as foliar application potassium nitrate (KNO_3), potassium thiosulphate (KSO_3) and potassium sulfate (K_2SO_4) which added with the rate of 5g K L^{-1} after 50 and 70 days, from sowing date in two seasons, respectively.

Phosphorus and potassium were broadcasted and incorporated during seed bed preparation according to recommendations of Agriculture Ministry. The recommended dose of nitrogen was added in a split application at 50% added preplanting and 50% after fifty days sowing. Plants were thinned after four weeks of sowing and the cultural practices and pest control were done as practiced by the local growers.

Cultivation:

The soil amendments were broadcast on 15 September 2014 and 23 September 2015 at preplant on the bed seeds of carrot rows. Carrot seeds were planted on 17 Sept. and 28 Sept. during 2014 and 2015 seasons, respectively. The seeds were conventionally broadcasted in upper ridges at 70 cm in width and 5 m length. Each plot included 3-ridges and the plot area was 10.5 m^2. The seeding rate was 4 kg fed^{-1}.

Plant sampling and chemical analysis: -

At harvest time (130 days after sowing), ten plants were randomly chosen from each sub-plot to record the plant fresh weight, root fresh weight, root length, root dry weight as well as carotenoid in roots. Further, all plants were weighted to estimate the yield of roots per plot in kg. Random plants were selected from each plot and be ready for chemical analysis. The organs of the plant were oven dried at 70°C; ground using stainless steel equipment to analyze N, P and K contents in both shoot and root. To achieve that, 0.2 g was digested by the mixture of sulfuric (H_2SO_4) and perchloric ($HClO_4$) acids (1:1) and nitrogen was determined using macro-Kjeldahl method according to Hesse (1971) While, phosphorus was determined calorimetrically at wavelength 430 nm using a spectrophotometer (Spekol) as described by (Cottenie *et al*., 1982). Total phosphorus was determined colorimetrically at wavelength 480 nm using spectrophotometer (Spekol) as described by Cottenie *et al.,* (1982). Total potassium was determined by using Gallen Kamp flame photometer as mentioned by Black (1965). Total carotenoids in roots were determined by using a spectro-colourimeter according to Wettstein (1957). Carbohydrate content in roots was determined according to Dubois *et al.,* (1956).

Statistical analysis:

Based on a two-way ANOVA, the effect of soil amendments and K-foliar application as well as their interactions were evaluated according to the procedure outlined by Duncan (1955) using CoStat (Version 6.303, CoHort, USA, 1998 -2004). Means of treatments were considered significantly different using the least-significant-differences test (LSD) at the confidence level of 5% according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant growth parameters: -

Data listed in Table 1 show that the soil amendments had a significant effect on root length, root fresh and dry weights in the two seasons. The highest men values of root length, fresh and dry weights of root were 15.89 and 14.47cm, 115.49 and 152.82, 21.33 and 20.41g $plant^{-1}$ obtained from the application of humic granules during both seasons, respectively. These followed by (14.07 and 12.57cm, 87.47 and 111.1, 20.03 and 19.88g $plant^{-1}$) with magnetic iron treatment during both seasons. On the other hand, the lowest mean values of studied parameters were 10.82 and 11.71cm, 65.38 and 87.69, 16.87 and 15.67g $plant^{-1}$ produced from without application. This increasing most probably was due to the improvement of water holding in the soil and supply the nutrients in the rhizosphere area of the plant (Selim *et al.,* 2009)

Regard with effect of K-sources, potassium nitrate (KNO_3) as a foliar application increased significantly all studied parameters more than other sources in both seasons. Moreover, humic substances granules plus KNO_3 was the superior treatment in increasing root length, fresh and dry weights of root in both seasons. The results of humic granules could be due to the role of humic acid which enhances photosynthetic process, stimulate root growth and development of chlorophyll and proliferation of desirable micro-organisms in soil (Liu *et al*., 1998). In addition, the slow release of humic acid from granules compared to humic powder. In this respect, Sadek and Youssef (2014) found that compost tea, K-humate and effective microorganism treatments enhanced available nitrogen in soil and soil organic matter and reduced soil pH compared to chemical treatment. Also, Belyavskaya (2001) found that magnetic treatment significantly induces cell metabolism and mitosis meristematic cells of lentil, pea, and flax. Furthermore, the formation of new protein bands in plants treated with magnetic iron may be responsible for the stimulation of all growth, and promoters in treated plants. In this respect, Çelik *et al.* 2008 mentioned that the increase in the percentage of plant growth was due to the effect of magnetic field on cell division and protein synthesis in paulownia node cultures.

Root yield:

The results in Table 2 clearly show that the combined effect of soil amendments and potassium foliar application had increasing all studied traits.

For the use of soil amendments, the maximum main values of fresh weight of plant were 153.34, 204.03 g $plant^{-1}$ and, 15.73, 16.94 kg $plot^{-1}$ produced from humic granules during both seasons, respectively. In addition, these parameters followed by (139.92 and 171.09 g $plant^{-1}$ 15.73 and 16.94 kg $plot^{-1}$) with magnetic iron treatment during both seasons. Contrary, the minimum mean values of studied parameters were 87.50 and108.43 g $plant^{-1}$, 10.50 and 11.30 kg $plot^{-1}$ produced from the unamended treatment.

Also, the benefit effect was shown by application of potassium foliar as KNO_3, KSO_3, and K_2SO_4 respectively. These results are aligned with those obtained by Salman *et al.,* (2005) who showed that the positive responses were obtained by application of humic acid. The growth promoting the activity of humic substances was caused by plant hormone-like material in the humic substances (Zhang and Ervin, 2004). Further, Canellas *et al.,* (2008) demonstrated that humic substances improve organic acids exudation by roots resulting in variations in morphological properties such as lateral-root density, primary root length, number of lateral roots. In addition, humic acid improves the metabolism processing of plants (Vaughan and Malcom, 1985; Vaughan *et al.,* 1985; Nardi *et al.,* 1996). These results suggest that K nutrition influences fresh weight by influencing carrot size and membrane integrity. Effects on cell water and osmotic potential are also important in this regard.

Table 1. Effect of soil amendments in combination with potassium foliar application on root length, fresh and dry weights (g plant^{-1}) of the root during 2014 and 2015 seasons.

Treatments		Root length (cm)		Root fresh weight (g plant^{-1})		Root dry weight (g plant^{-1})	
		2014	2015	2014	2015	2014	2015
Mean values as affected by soil amendments							
Without		10.82d	11.71c	65.38c	87.69d	16.87d	15.67d
Magnetic iron		14.07 b	12.57 b	87.47 b	111.15b	20.03b	19.88b
Humic granules		15.89 a	14.47 a	115.49 a	152.80a	21.33a	20.41a
Humic powder		13.11c	11.79c	85.41b	98.69c	19.68c	18.55c
Mean values as affected by K- foliar application							
KNO_3		14.54 a	14.39a	107.73a	128.95a	20.92a	19.97a
KSO_3		13.04b	12.55b	87.26b	108.64b	19.18b	18.49b
K_2SO_4		12.83b	10.96c	70.34c	100.16c	18.33c	17.42c
Soil amendments		K- fertilizer sources					
	KNO_3	11.35g	13.06cd	73.70f	101.24g	17.85 g	17.03 f
Without	KSO_3	10.59g	11.63f	66.82g	83.92i	16.62 h	15.15 g
	K_2SO_4	10.52g	10.43g	56.29h	77.92 j	16.14 h	14.83 h
	KNO_3	14.90b	13.50c	98.71c	133.48d	21.32bc	20.81b
Magnetic iron	KSO_3	13.83d	11.55f	88.65d	106.87f	20.23 d	19.41d
	K_2SO_4	13.48de	10.33g	68.85g	93.12h	18.52 f	19.42d
	KNO_3	18.00a	16.69a	144.96a	165.78a	22.92 a	21.91a
Humic granules	KSO_3	14.93b	14.27b	115.86b	150.87b	20.74cd	21.11b
	K_2SO_4	14.73bc	12.44e	85.66d	141.75c	20.33 d	18.22e
	KNO_3	13.94cd	14.31b	113.52b	115.31e	21.58 b	20.11 c
Humic powder	KSO_3	12.81ef	12.75de	78.35e	92.91h	19.13 e	18.32 e
	K_2SO_4	12.58 f	10.64g	70.53fg	87.84hi	18.34fg	17.22 f

Values in each column followed by the same letters are non-significant different at *P* ≤0.05.

Table 2. Effect of soil amendments in combination with potassium foliar application on plant fresh weight, yield, carbohydrate and total carotenoid in roots for carrot during 2014 and 2015 seasons.

Treatments		Plant fresh weight (g.plant^{-1})		Yield (kg.plot^{-1})		Carbohydrate (mg.100ml^{-1})		Carotenoids (g)	
		2014	2015	2014	2015	2014	2015	2014	2015
Mean values as affected by soil amendments									
Without		87.50d	108.43d	10.50d	11.30d	32.90d	31.81d	5.58d	5.42c
Magnetic iron		139.92b	171.09b	13.79b	14.92b	49.90b	53.78b	8.05b	6.02b
Humic granules		153.34a	204.03a	15.73a	16.94a	57.44a	57.51a	9.07a	7.58a
Humic powder		96.20c	124.74c	12.49c	12.56c	44.35c	41.82c	7.46c	5.99b
Mean values as affected by K- foliar application									
KNO_3		138.78a	177.83a	14.15ab	14.65a	50.12a	51.58a	8.19a	6.68a
KSO_3		121.32b	147.22b	13.16b	13.86b	46.27b	45.92b	7.47b	6.21b
K_2SO_4		97.62c	131.17c	12.08c	13.29c	42.05c	41.19c	6.94c	5.86c
Soil amendments		K-fertilizer Sources							
	KNO_3	101.14 f	132.14g	11.35f	11.84i	38.81g	36.11i	6.14 f	5.74 de
Without	KSO_3	89.15g	100.31i	10.34g	11.39j	33.29h	31.61j	5.53 g	5.14 f
	K_2SO_4	72.20h	92.83 j	9.79h	10.67k	26.61i	27.72k	5.06 g	5.37 ef
	KNO_3	158.62b	190.38c	14.54c	15.76d	52.30c	57.72b	8.74 bc	6.53c
Magnetic iron	KSO_3	143.35c	167.92e	14.11d	14.67e	49.63d	53.61d	8.07 d	6.12cd
	K_2SO_4	117.80e	154.97f	12.72e	14.33f	47.77e	50.02e	7.32 e	5.39 ef
	KNO_3	172.78a	233.12a	16.96a	17.45a	59.04a	65.71a	9.63 a	8.18 a
Humic granules	KSO_3	163.18b	204.41b	15.52b	17.07b	58.81a	56.83c	9.20 ab	7.44 b
	K_2SO_4	124.05d	174.56d	14.70c	16.30c	54.49b	50.01e	8.36 cd	7.11b
	KNO_3	122.58de	155.65f	13.73d	13.53g	50.34d	46.79f	8.27 cd	6.26 cd
Humic powder	KSO_3	89.61g	116.24h	12.65e	12.29h	43.36f	41.66g	7.08 e	6.15 cd
	K_2SO_4	76.41h	102.32i	11.08f	11.87i	39.36g	37.03h	7.03 e	5.57 ef

Values in each column followed by the same letters are non-significant different at *P*≤0.05.

Root quality indices:

Data presented in Table 2 showed that soil amendments significantly influenced carbohydrate and carotenoids content of root. The given data indicated that there was a gradual increase in the concentration of carbohydrate and carotenoids content by adding humic granules, magnetic iron, and humic powder, respectively compared with unamended treatments. This result was true for both growing seasons. In addition, obtained results in the same Table illustrated that foliar potassium application caused a gradual increase in these parameters concentration of roots. The highest concentration of both mentioned above was detected under the humic granules with potassium nitrate, whereas the interaction between the treatments was significant in carbohydrate content only. Furthermore, Karimi *et al.* (2012) reported that magnetic field treatment enhances stress tolerance of plant by increasing water absorption, increasing WUE, and inducing proline accumulation and carotenoids content in plants leaves.

Macro-nutrients uptake: -

Nutrients uptake of carrot shoots was significantly increased due to the soil amendments plus potassium foliar application as shown in Table 3.

Table 3. Effect of soil amendments in combination with potassium foliar application on N, P and K nutrients uptake (mg plant^{-1}) in shoots of carrot during two successive seasons of 2014 and 2015.

Treatments		Nitrogen		Phosphor		Potassium	
		2014	2015	2014	2015	2014	2015
Mean values as affected by soil amendments							
Without		438.54d	382.26d	11.89d	10.56d	290.99d	288.06 d
Magnetic iron		617.44b	613.97b	20.86b	20.11b	467.01b	412.586b
Humic granules		712.26a	696.34a	26.00a	22.79a	549.87a	467.42a
Humic powder		586.29c	490.98d	16.14c	16.12c	379.20c	366.28c
Mean values as affected by K- foliar application							
KNO_3		659.41a	612.87a	22.16a	20.94a	484.12a	434.40a
KSO_3		576.25b	540.77b	18.12b	16.57b	416.34b	375.28b
K_2SO_4		530.23c	483.99c	15.88c	14.68c	364.85c	341.07c
Soil amendments	K-fertilizer Sources						
Without	KNO_3	486.44g	438.66g	13.77e	14.98ef	324.20f	334.59g
	KSO_3	425.69h	366.60h	11.56f	7.74g	282.87g	277.07h
	K_2SO_4	403.48i	341.39i	10.35f	8.97g	265.92g	252.53i
Magnetic iron	KNO_3	688.00b	669.31c	23.98b	22.43bc	532.63b	453.87c
	KSO_3	613.97d	590.37d	20.29c	19.19cd	473.05c	391.92e
	K_2SO_4	550.35ef	582.21d	18.29d	18.70d	395.35e	391.93e
Humic granules	KNO_3	809.88a	789.42a	31.24a	27.03a	630.85a	540.57a
	KSO_3	693.77b	718.55b	25.50b	22.81b	532.70b	474.16b
	K_2SO_4	633.97cd	581.08d	21.28c	18.54d	486.06c	387.55e
Humic powder	KNO_3	653.33c	554.09e	19.67cd	19.33cd	448.83d	408.61d
	KSO_3	571.57e	487.54f	15.13e	16.52de	376.72e	358.00f
	K_2SO_4	533.97f	431.31g	13.61e	12.50f	312.08f	332.24g

Values in each column followed by the same letters are non-significant different at $P \leq 0.05$.

In the current study, the different soil amendments had a significant effect on N, P and K nutrients uptake in shoots during both growing seasons. Humic granules and magnetic iron led to gradual significant increasing N, P and K nutrients uptake in shoots compared with humic powder application. Concerning the potassium fertilizers, the superiority in N, P and K uptake were observed with KNO_3 application compared with other three treatments during both seasons. While, the minimum means were obtained under control treatment. As the combination of soil amendments and K-sources, data showed that humic granules and magnetic iron with KNO_3 application foliar revealed the highest significant means of NPK uptake in shoots of carrot compared with the other treatments. The highest mean values of absorbed N, P and K nutrients by shoots were 809.88 and 789.42 for N, 31.24 and 27.03 for P, 630 and 540.57 mg plant^{-1} for K obtained from the application of humic granules plus KNO_3 source during both seasons, respectively. On the other hand, the lowest mean values of N, P and K uptake of shoots were 403.48 and 341.39 for N, 10.35 and8.97 for P, 265.92 and 252.53 mg plant^{-1} occurred with the absence of soil amendment treatment. The present results were conflicted with those obtained by Sudhakar *et al.* 2002, Abd El-Al 2003, Esitken and Turan 2004, Taha *et al.* 2011 and Yusuf and Ogunlela 2015.

In addition, the results revealed that soil amendments positively affected the nutritional status of carrot roots. Plants treated with humic granules had significantly increased root uptake NPK nutrients compared with untreated plants as presented in Table 4.

Moreover, all previously mentioned characters were progressively and significantly increased with potassium application as the following order; KNO_3> KSO_3> K_2SO_4 respectively. Results revealed that the interaction between different soil amendments and different sources of potassium foliar application had promoted effect on N, P and K nutrients in root tissues. Soil application of humic granules combined with foliar KNO_3 which gave the highest significant means in N, P and K nutrients uptake compared with other treatments. Oppositely, the lowest one was obtained by the absence of soil amendment treatment (control) plus foliar application of K_2SO_4during both seasons. Further, the stimulatory effect of magnetic treatment may be attributed to the improved in capacity for nutrient and water uptake.

Providing greater physical support to the developing shoot, better root growth and development in young seedlings might lead to better root systems throughout the lifetime of a plant (Taha *et al.,* 2011). Similar findings mentioned by Machado *et al*., (2004) and Ibrahim and Kazim (2008). Also, De Souza *et al.,* (2005) recorded that magnetic treatments led to a remarkable increase in plant root and stem height as well as fresh and dry weights during the nursery period of the tomato plant. The magnetic field may play an important role in cation uptake capacity and has a positive effect on immobile nutrient uptake by the plant, for example with Ca and Mg nutrients (Esitken and Turan 2004).

Table 4. Effect of soil amendments and source of potassium foliar application as well as their interactions on N, P and K nutrients uptake (mg plant-1) in roots of carrot during two successive seasons of 2014 and 2015.

Treatments		Nitrogen		Phosphor		Potassium	
		2014	2015	2014	2015	2014	2015
Mean values as affected by soil amendments							
Without		345.82d	426.52d	33.53d	27.27 d	526.58d	485.26d
Magnetic iron		539.77b	661.12b	48.12b	44.72b	869.85b	793.95b
Humic granules		646.77a	722.04a	58.15a	51.33a	995.67a	843.90a
Humic powder		460.57c	554.17c	42.07c	38.42c	733.28c	646.77c
Mean values as affected by K- foliar application							
KNO_3		582.11a	683.75a	52.18a	46.46a	895.22a	780.12a
KSO_3		485.82b	574.06b	44.64b	39.68 b	756.50b	680.64b
K_2SO_4		426.77c	515.08c	39.60c	35.18c	692.34c	616.67c
Soil Amendments	K-fertilizer Sources						
Without	KNO_3	417.43f	532.94g	37.41f	34.74f	619.56g	561.87g
	KSO_3	333.18g	380.25i	32.42g	23.78g	495.37h	471.15h
	K_2SO_4	286.86h	366.38i	30.34h	23.29g	464.84i	422.76i
Magnetic iron	KNO_3	620.47b	738.79b	54.15c	49.53c	946.69b	861.58c
	KSO_3	538.43cd	626.91de	48.16d	42.90d	868.16d	764.71d
	K_2SO_4	460.41e	617.68e	42.06e	41.77d	794.70e	755.57d
Humic granules	KNO_3	762.20a	823.77a	69.01a	58.72a	1125.72a	924.57 a
	KSO_3	617.68b	715.66c	56.84b	53.20b	958.44b	880.31b
	K_2SO_4	560.45c	626.70de	48.67d	42.07d	902.85c	726.83e
Humic powder	KNO_3	528.35d	639.51dd	47.69d	42.85d	888.88cd	772.42d
	KSO_3	454.00e	573.44f	41.13e	38.84e	704.01f	606.37f
	K_2SO_4	399.36f	449.58h	37.41f	33.58f	606.97g	561.52g

Values in each column followed by the same letters are non-significant different at $P \leq 0.05$.

CONCLUSION

The obtained results concluded that the all previously mentioned characters were progressively and significantly increased with foliar application of potassium fertilizers as the following order; KNO_3 > KSO_3 > K_2SO_4 respectively. Further, soil application of humic substances caused marked increases on vegetative growth, yield and N, P and K nutrients uptake in both shoots and roots of carrot plants as well as carbohydrate and carotenoids content as the following order; humic granules > magnetic iron >humic powder, respectively. Finally, the combination with soil application of humic granules and KNO_3 as the foliar application is considered as a promising technique for improving the productivity of carrot plant as well as a progressive increase in its uptake compared with other treatments under clay soil conditions.

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إستجابة الجزر للتسميد الورقي بالبوتاسيوم وبعض محسنات التربة تحت ظروف الأراضي الطينية

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أجريت تجربتين حقليتين خلال الموسم الشتوي لعامي 2014 و2015 في المزرعة البحثية بالبرامون – محافظة الدقهلية وذلك لدراسة تأثير الحديد المغناطيسي ومركبات الهيوميك (حبيبات ومسحوق) كمحسنات تربة مع إضافة مصادر مختلفة لعنصر البوتاسيوم رشاً (نترات بوتاسيوم ، ثيوسلفات البوتاسيوم ، سلفات البوتاسيوم) على الجودة والمحصول لنبات الجزر صنف شنتناي. وقد أوضحت النتائج أن إضافة مركبات الهيوميك في صورة حبيبات وكذلك إضافة الحديد المغناطيسي أدى إلى زيادة معنوية في الصفات الخضرية والمحصول ومحتوى الأوراق والجذور من عناصر النيتروجين والفوسفور والبوتاسيوم. وكذلك محتوى الجذور من الكربوهيدرات والكاروتين. كما أدى إضافة البوتاسيوم رشاً إلى زيادة معنوية في كل الصفات تحت الدراسة خاصة مع إضافة البوتاسيوم في صورة نترات البوتاسيوم بالمقارنة مع مصادر البوتاسيوم الأخرى. وقد كان للتفاعل بين مركبات الهيوميك في صورة حبيبات والرش بنترات البوتاسيوم تأثيراً معنوياً موجباً على كل من صفات النمو الخضري والمحصول وكذلك محتوى النبات من عناصر النيتروجين والفوسفور والبوتاسيوم إضافة إلى محتوى الجذور من الكربوهيدرات والكاروتين. وتوصي الدراسة بإمكانية إضافة نترات البوتاسيوم رشاً ومع استخدام مركبات الهيوميك في صورة حبيبات أو الحديد المغناطيسي كمحسنات تربة للحصول على أعلى إنتاجية مع أفضل صفات جودة لجذور نبات الجزر صنف شنتناي تحت ظروف التربة الطينية.