J. of Plant Production, Mansoura Univ., Vol. 11 (11):1035-1040, 2020

Journal of Plant Production

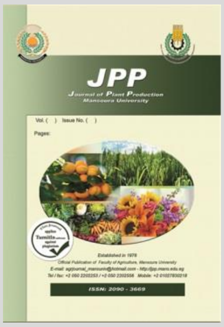
Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Effect of Foliar Application of Different Potassium Forms on the Growth and Flowering of Snapdragon (*Antirrhinum majus* L.) Plants

Cross Mark

Abd El Gayed, M. E.[1*] and R. E. Knany[2]

[1] Botanical Gardens Research Department, Horticulture Research Institute - Agriculture Research Center, Giza, Egypt
[2] Soils, Water and Environmental Research Institute - Agriculture Research Center, Giza, Egypt



ABSTRACT

A pot experiment was conducted during 2018 and 2019 seasons in Sakha Horticulture Research Station, Kafr El-Sheikh Governorate, Egypt to study the effect of foliar application of potassium sulphate 50%, potassium nitrate 43% (1, 2 and 3 g/l water) and potassium silicate 38% (1, 2 and 3 ml/l water) on growth and flowering of snapdragon *(Antirrhinum majus* L.) plants. The results indicated that foliar spraying with the different potassium treatments significantly affected all the studied parameters in terms of plant height, number of shoots per plant, fresh and dry weight of plant, roots and flower, number of flowers per plant, spike length, total chlorophyll content and nutritional status (N, P, K and Si) as compared with control. Foliar spraying with potassium sulphate at 3 g/l water gave the significantly highest values of plant height, number of shoots per plant, fresh and dry weight of plant, roots and flower, number of flowers per plant, spike length and total chlorophyll compared to other treatments. Data showed also that, growth parameters, flowering characteristics and nutritional status were significantly increased with increasing the levels of potassium from 1 to 3 g/l water or ml/l water under the same source of potassium. So, it can be concluded that potassium foliar spray can be used as a partial substitution of the recommended soil amended potassium for increasing nutrients uptake and thus stimulating growth and flowering characteristics of snapdragon *(Antirrhinum majus* L.) plants and potassium sulphate at 3 g/l water can be used in this respect.

Keywords: potassium, sulphate, nitrate, silicate, growth, flowering, ornamental plants

INTRODUCTION

Snapdragon *(Antirrhinum majus* L.) plant is one of the member of Scrophulariaceae family which its plants are characterized by its beauty and their heights are varied according to their cultivars are tall and their flowers are used as cut flowers, while the short ones are used as pot plants (Tolety and Sane, 2011). Fertilizers give nutrition to the plant which gave healthy growth and increasing flower yield with high quality. Snapdragon *(Antirrhinum majus* L.) plants shows a great response to adding fertilizers as foliar spraying; there is an increase in number of leaves, number of branches, longevity of inflorescence and number of lateral inflorescences (Mjeed and Ali 2017; Malik *et al.*, 2019 and Verma *et al.*, 2019). The production of commercialized flowers is considered one of the remarkable operations spread globally and the demand required certain conditions such as colorful and fragrant flowers. Therefore, snapdragon *(Antirrhinum majus* L.) plants productivity hang upon the amounts, forms and frequency of plant nutrients especially potassium. Potassium (K^+) is highly mobile in plants and constitutes up to 10% of plant dry weight (Adams and Shin, 2014 & Shin, 2014). Regarding the total amount of mineral nutrients required by plants, potassium is required in the largest amount after nitrogen (Zorb *et al.*, 2014). Potassium activates numerous enzymes, which are critical for various metabolic processes, such as biosynthesis, transport, and transformation of sugar and starch (Karley and White, 2009 & Romheld and Kirkby, 2010). Furthermore, potassium is an essential nutrient involved in the phloem translocation of assimilates, including sucrose movement from shoot to root (Hammond and White, 2008). Also, potassium is considered as a major role osmotically active cation of plant cell (Hasanuzzaman *et al.*, 2018) where potassium enhances water uptake and root permeability and acts as a guard cell controller, beside its role in increasing water use efficiency (Sustr *et al.*, 2019). Potassium is an essential mineral element for nutrition in flowering plants, for its role in production and flower quality, although it is not a constituent of any plant part, it affects the metabolism of nitrogen, carbohydrates and the synthesis of lipid, starch and protein (Hasanuzzaman *et al.*, 2018). Foliar spraying with potassium fertilizer on ornamental plants as single or a combination of nutrients has become an excellent procedure for increasing growth, and improving productivity and quality of flowers. In this respect, Hamayl *et al.*, (2016) found that fertilizing *Dahlia pinnata*, L. plants with potassium sulfate at 10 and 20 g/plant showed a positive effect on vegetative growth parameters i.e. plant height, number of leaves, number of shoots, stem diameter and dry weight % of plants. It also induced an increment in flowers and tubers parameters such number of flowers, flower diameter, flower stem length and diameter as well as flower adherence strength, vase life, number of tubers/plant and tuber diameter. El-Naggar and El-Nasharty (2016) revealed that spraying *Gladiolus hybrid* a plants with potassium sulphate at 1 and 2% had significantly affected all the studied parameters compared to the control as gave the highest values of plant height, number of leaves per plant, fresh and dry weight of leaves,

[*] **Corresponding author.**
E-mail address: abdelgayedm2020@gmail.com
DOI: 10.21608/jpp.2020.122660

number of florets per spike, floret diameter, spike length, fresh and dry weights of florets, new corm diameter, fresh weight and cormlets number per plant as well as leaf chlorophyll a and b and petals anthocyanins content. Various sources of potassium fertilizers affect growth, flowering and quality of ornamental plants. In this regard, Yassen *et al.,* (2010) and El-Gamal (2015) revealed that application of potassium fertilizer from different sources affected growth and quality of flower of *Calendula officinalis* plants. El-Sayed (2012) indicated that fertilization of tuberose with potassium nitrate at 2 g/pot, potassium citrate at 2 ml/l, potassein-N or potassein-P at 2 ml/l produced the greatest number of leaves per plant, leaf length, leaf fresh and dry weight, flowering stalk length, diameter and fresh and dry weights as well as florets number per spike. Also, the application of KNO_3 had a great impact on growth and flower production of *Tagetes erecta* plants (Dhatt *et al.,* 2019). Dorgham (2019) on *Zinnia elegans* indicated that potassium sources as sulphate, nitrate, chloride, humate and citrate each at 1000 ppm had positive effects on improving the growth characters and increasing the flower yield. Also, Shyala *et al.,* (2019) reported that *Tagetes erecta* plants sprayed with potassium humate at 1% significantly increased growth, flowering characters and flower yield per plant.

In light of the above facts this study was carried out to find the influence of foliar application of different sources and levels of potassium fertilizers on the growth and flowering of Snapdragon (*Antirrhinum majus* L.) plants.

MATERIALS AND METHODS

A pot experiment was carried out during 2018 and 2019 seasons at Sakha Horticulture Research Station, Kafr El-Sheikh Governorate, Egypt to study the effect of foliar sprays of different sources and levels of potassium on vegetative growth and flowering of snapdragon (*Antirrhinum majus* L.) plants. The seeds were sown in cork trays containing peat moss and vermiculite (1:1 v / v) on October 10th in both growing seasons. After 5 weeks seedlings were transplanted in polyethylene pots of 25 cm diameter containing 8 kg from sandy clay soil as growing media (2 clay: 1 sand v/v) and it was stayed in open field . Soil samples were taken before the establishment of the study of physical and chemical properties (Table, 1) according to Jackson (1967). When plants reached 15-20 cm in length approximately, 150 seedlings were selected uniformly and arranged in a completely randomized design (C.R.D.) with three replicate, each replicate contained five plants. All plants received equal dose (4g/pot) from ammonium nitrate (33%N) and calcium super phosphate (15.5% P_2O_5) as a source of nitrogen and phosphorus, and regularly irrigated with tap water. The experiment included ten treatments as follows; control (sprayed with tap water) in addition potassium sulphate (50 %), potassium nitrate (43 %) at three concentrations, i.e., 1, 2 and 3 g/l water as well as potassium silicate (38 %) at three concentrations, i.e., 1, 2 and 3 ml/l water The plants were sprayed after three weeks from transplanting in the early morning to the run off by using a manual sprayer.

Table 1. Physical and chemical properties of the used soil

Ec (dSm^{-1})	**O.M (%)**	**pH**	**Soluble cations (meq/l)**				**Soluble anions (meq/l)**		
			Ca^{++}	**Mg^{++}**	**K^{+}**	**Na^{+}**	**SO_4^{--}**	**HCO_3^{-}**	**Cl^{-}**
1.36	1.24	7.79	3.5	2.98	0.18	6.93	4.03	7.90	1.66
Particle size divisions (%)			Textural class	Available nutrients (ppm)					
Sand	Silt	Clay		N		P		K	
36.37	21.50	42.13	Clayey Sand	233.75		1.31		440.15	

The recorded vegetative growth characters included plant height (cm), shoot number per plant, fresh and dry weight of top vegetative area and roots. Total chlorophylls in fresh leaf samples were determined by using chlorophyll Meter model SPAD 502 according to Netto *et al.,* (2005). The flowering characters were expressed as spike length, number of inflorescence per plant and fresh and dry weights of inflorescence. Nutritional status, ten mature leaves/ plant (the fifth leaf from the top of the plant) were sampled in both seasons, washed, dried at 70°C to a constant weight, ground and digested for determination leaf minerals content. Nitrogen was determined by Micro-kjeldahle method as outlined by Chapman and Pratt (1978). Phosphorus was determined using spectrophotometer according to Murphy and Riely (1962). Potassium was determined by flame photometer according to Jackson (1967), while, leaf silicon content was determined according to Dai *et al.,* (2005).

Statistical analysis

The data were statistically analyzed as analysis of variance according to Snedecor and Cochran (1990) Duncan's multiple range test (DMRT) was used to compare the main values(Duncan,1955).

RESULTS AND DISCUSSION

1- Vegetative and root growth:

a- Plant height:

The results presented in Table (2) indicated that, all potassium foliar application treatments significantly increased plant height as compared to control treatment in both seasons. Moreover, plant height was significantly increased with increasing the levels of potassium from 1 to 3 g/l or ml/l under the same source of potassium. These results were true in both seasons. Snapdragon (*Antirrhinum majus* L.) plants sprayed with potassium sulphate at 3 g/l gave the tallest plants followed by those sprayed with potassium nitrate at 3 g/l and potassium silicate at 3 ml/l in both seasons, respectively. The shortest plant was found from plant under control treatment. Similar results were obtained by El-Nagar and El-Nasharty (2016) on *Gladiolus hybrida* and Hamayl *et al.,* (2016) on Dahlia. In this respect, Dorgham (2019) concluded that *Zinnia elegans* sprayed with potassium sulphate, nitrate, chloride, humate and citrate each at 1000 ppm gave the tallest plant height especially under potassium citrate and humate.

b- Number of shoots per plant:

Data presented in Table (2) showed that the significantly highest values of number of shoot per plant was detected in plants sprayed with potassium sulphate at 3g/l followed by potassium nitrate at 3 g/l and potassium silicate at 3 ml/L in both seasons. The lowest values of number of shoot per plant were observed in control treatment. Furthermore, it was noticed that number of shoots per plant was increased with increasing levels on each source of potassium. These findings are in line with those of El-Gamal (2015) on *Calendula officinalis* and Shyala *et al.,* (2019) on

Tagetes erecta plants. In this regard, Heikal (2017) reported that *Salvia farinacea* sprayed with potassium sulphate at 2 g/l, potassium citrate at 2 g/l and potassium humate at 3 g/l gave the higher number of branches/plant than that on control treatment; and also concluded that potassium citrate gave the best results in this respect as compared with the other potassium sources.

c- Total chlorophyll (SPAD):

The presented results in Table (2) revealed that, total chlorophyll was significantly enhanced by foliar application of the different sources of potassium in both seasons. The amounts of total chlorophyll in leaves are proportional with concentration of potassium, it means that total chlorophyll was increased with increasing the concentration of potassium; this result was true in both seasons. Spraying snapdragon (*Antirrhinum majus* L.) plants with potassium nitrate at 3 g/l gave the highest content of total chlorophyll followed by potassium sulphate at 3 g/l and potassium silicate at 3ml/l in both seasons, respectively. In contrary, the lowest values of total chlorophyll found in plants sprayed with tap water (control). The positive effect of foliar application of different sources of potassium on total chlorophyll was reported by Hashem (2016) on *Calendula officinalis* and Ashour *et al.*, (2018) on *Euryops pectinatus*. In this respect, Pal and Ghosh (2010) cleared that total chlorophyll content in leaves of *Tagetes erecta* plants was gradualy increased with increasing levels of potassium. The increment in leaf chlorophyll contents as a result of foliar application of potassium might be due to: potassium enhanced nutrients uptake especially nitrogen, this led to more chlorophyll formation, which reflected on more photosynthesis and accumulation of more carbohydrates which improve growth and productivity of plants. These explanations agree with our data in Tables (2 and 3) and El Naggar and El Nasharty (2016) as concluded that foliar application of potassium sulphate at 2% tended to improve leaf total chlorophyll content in *Gladiolus hybrida*, L. cv."Rose Supreme".

Table 2. Effect of foliar application of different potassium forms on plant height and number of shoot/plant and total green colour of leaves of snapdragon *(Antirrhinum majus* L.) plants during 2018 and 2019 seasons

Treatments		Plant height (cm)		Number of shoots per plant		Total green colour (SPAD)	
		2018	2019	2018	2019	2018	2019
Control		66.33f	69.33f	15.00g	15.67f	26.37e	26.83e
Potassium sulphate (K_2SO_4)	1 g/L	75.67d	77.67d	19.67de	20.67cd	27.90cde	28.43e
	2 g/L	89.00b	89.00b	22.00bc	23.00b	31.70b	32.60c
	3 g/L	94.33a	96.33a	25.67a	25.67a	35.50a	35.63b
Potassium nitrate (KNO_3)	1 g/L	72.33e	73.67e	18.33ef	19.33de	28.70cd	28.23e
	2 g/L	81.00c	84.33c	20.67bcd	20.67cd	31.93b	32.70c
	3 g/L	93.67a	91.00b	24.33a	23.00b	36.27a	37.63a
Potassium silicate (K_2SiO_3)	1 ml/L	73.67de	74.33e	17.33f	17.67e	27.13de	27.27e
	2 ml/L	79.67c	82.67c	20.33cd	20.33cd	29.67c	30.43d
	3 ml/L	87.67b	90.67b	22.33b	22.00bc	34.53a	34.97b

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

d- Fresh weight / plant and root:

Data presented in Table (3) showed that, fresh weight per plant and root fresh weight were significantly increased due to spraying different potassium sources on napdragon (*Antirrhinum majus* L.) plants compared to those sprayed with tap water (control) in both seasons. Spraying with potassium sulphate at 3 g/l produced the heaviest fresh weight / plant and root fresh weight followed by potassium nitrate at 3 g/l and potassium silicate at 3 ml/l in both seasons. On the other hand, control treatment had the lowest values of fresh weight / plant or root fresh weight with significant differences between control and other treatments in both seasons. These findings are in agreement with those obtained by Yassen *et al.,* (2010) and Heikal (2017).

Table 3. Effect of foliar application of different potassium forms on fresh and dry weight/plant, root fresh weight and root dry weight of Snapdragon *(Antirrhinum majus* L.) plants during 2018 and 2019 seasons

Treatments		Fresh weight / plant(g)		Dry weight / plant(g)		Root fresh weight (g)		Root dry weight (g)	
		2018	2019	2018	2019	2018	2019	2018	2019
Control		48.24f	48.34f	11.28d	10.63d	8.18f	8.28g	1.84h	1.87g
Potassium sulphate (K_2SO_4)	1 g/L	58.68d	57.08e	12.52cd	11.81c	9.32e	9.56f	2.20fg	2.20f
	2 g/L	66.58c	65.58c	13.83b	13.43b	11.39d	11.52d	2.74d	2.68d
	3 g/L	80.96a	80.98a	15.72a	15.28a	15.22a	15.42a	3.51a	3.55a
Potassium nitrate (KNO_3)	1 g/L	54.75de	55.66e	11.96cd	12.40bc	8.66ef	8.64g	2.02gh	2.12f
	2 g/L	64.64c	62.87cd	12.47cd	12.47bc	10.63d	10.46e	2.52e	2.49e
	3 g/L	72.35b	72.77b	15.16a	15.03a	14.02b	14.17b	3.21b	3.24b
Potassium silicate (K_2SiO_3)	1 ml/L	52.87ef	53.40e	12.30cd	12.67bc	8.48f	8.79g	2.04g	2.12f
	2 ml/L	58.35de	58.37de	12.91bc	13.01bc	9.44e	9.71f	2.27f	2.35e
	3 ml/L	65.66c	66.76c	15.14a	15.10a	12.38c	12.36c	3.02c	3.06c

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

e- Dry weight / plant and root:

It is quite clear from data presented in Table (3) that foliar application of potassium fertilizer from different sources; potassium sulphate, nitrate and silicate significantly affected dry weight per plant and root dry weight of Snapdragon (*Antirrhinum majus* L.) plants. Dry weights of plant and root were significantly increased in both seasons as compared with the control. Similar results were obtained by Shyala *et al.*, (2019) who found that potassium application increased dry weight per plant as compared with control. Moreover, spraying with potassium sulphate at 3 g/l produced the heaviest dry weights of plant and root followed by potassium nitrate at 3 g/l and potassium silicate at 3 ml/l in both seasons. On the other hand, control treatment had the lowest values of dry weights of plant and root with significant differences between control and other treatments in both seasons. These results are in accordance with those obtained by El-Gamal (2015) and Heikal (2017).

In general, it is clear from Tables (2 and 3) that, foliar application of potassium significantly improved growth and size of snapdragon (*Antirrhinum majus* L.) plants. Potassium nutrient produced vigour and tallest plants, more formation of shoots and high values of fresh and dry weights of plant and roots, this effect was much pronounced with raising concentration of potassium used. Moreover, spraying with potassium sulphate at 3 g/L gave the best vegetative growth parameters comparing with the other treatments. Increasing vegetative growth of snapdragon (*Antirrhinum majus* L.) plants as a result of the effect of foliar application of potassium may be due to the fact that the potassium is one of the necessary elements for plant growth and development, although it does not enter into the composition of any of the cellular components and plays the catalyst role in many bioprocesses, including the process of protein formation and photosynthesis (Hasanuzzaman *et al.,* 2018). This leads to an increase in the vegetative growth of the plant, represented by plant height and number of leaves, as well as the role of potassium in stimulating the different enzymatic systems and regulating the osmotic pressure of cells and the process of opening and closing the stomata (Wang *et al.,* 2013). It is due to the role of potassium in maintaining cell swelling pressure and contributing to improving cell growth and elongation and with nitrogen present, they contributed to increased vegetative growth and improvement of metabolic processes and then increased plant height (Zaman *et al.,* 2015). Potassium also plays an effective role in the division of the meristem cells and the absorption of nutrients. The presence of potassium in a balanced manner with the rest of the other elements leads to the formation of a good root system that reflects positively on the increase of the plant's absorption of nutrients.

2- Flowering characteristics:

a- Number of flowers per plant:

Results presented in Table (4) revealed that, number of flowers per plant of was significantly responded to different potassium sources as compared to control plants. The highest flowers production per plant was obtained from plants sprayed with potassium sulphate at 3 g/l followed by potassium nitrate at 3 g/l and potassium silicate at 3 ml/l in both seasons. On the other hand, plants in control treatment gave the lowest values of number of flowers per plant in both seasons. The differences were significant among treatments in both seasons. These results were similar to those obtained by El-Gamal (2015) and El Naggar and El Nasharty (2016).

b- Spike length:

It is obvious from data presented in Table (4) that the highest values of spike height was recorded as a result of foliar spraying of different potassium forms and levels compared to control for both seasons. Potassium sulphate at 3 g/l gave the tallest spike height followed by potassium nitrate at 3 g/l and potassium silicate at 3 ml/l in both seasons. On the other hand, control treatment produced the shortest spike with significant differences between control and other treatments in both seasons. Also, the results indicated that spike height was increased with increasing concentration of the sprayed solution. Similar results were obtained by Dorgham (2019).

c- Fresh and dry weight of inflorescence:

Presented data in Table (4) revealed that the fresh and dry weight of inflorescence was significantly increased by the foliar application of potassium sulphate, nitrate and silicate as compared with the control in both seasons. In this respect, potassium sulphate at 3 g/l produced the heaviest fresh and dry weight of flower followed by potassium nitrate at 3 g/l and potassium silicate at 3 ml/l as compared with the other treatments in both seasons. In contrast, the lowest values of fresh and dry weights were observed in control treatment in both seasons. These results are in agreement with those found by El-Sayed (2012), El-Gamal (2015) and Hamayl *et al.,* (2016). This can be explained by the role of potassium, which plays an important role in carbohydrates metabolism and enzymes activity,. affecting flower weight, and increase dry matter accumulation (Hasanuzzaman *et al.,* (2018)In this respect, Abbadi *et al.,* (2008) stated that flowers increased with increasing K supply. Also, Heikal (2017) and Shah *et al.,* (2018) reported that potassium nitrate, citrate and humate had a positive impact on increasing fresh and dry weight of flowers.

Table 4. Effect of foliar application different potassium forms on number of flowers/plant, spike length, flower fresh and dry weight of snapdragon *(Antirrhinum majus* L.) plants during 2018 and 2019 seasons

Treatments		Number of flowers/plant		Spike length (cm)		Flower fresh weight (g)		Flower dry weight (g)	
		2018	2019	2018	2019	2018	2019	2018	2019
Control		42.00h	41.00h	30.00g	30.00e	14.71h	14.21f	2.19g	2.38f
Potassium sulphate (K_2SO_4)	1 g/L	47.33f	45.67f	33.33ef	34.33c	18.30f	17.50e	2.89e	2.74e
	2 g/L	51.00d	52.33c	38.00c	38.33b	20.74d	21.81c	3.57c	3.56c
	3 g/L	58.00a	58.67a	42.33a	40.67a	26.30a	28.37a	4.38a	4.51a
Potassium nitrate (KNO_3)	1 g/L	44.67g	44.00g	31.67fg	31.33d	16.67g	16.43e	2.59f	2.57ef
	2 g/L	49.67e	50.33d	35.67d	34.67c	19.87de	20.41d	3.26d	3.27d
	3 g/L	55.33b	54.33b	40.33b	40.67a	23.80b	23.73b	3.98b	3.91b
Potassium silicate (K_2SiO_3)	1 ml/L	44.67g	45.00fg	31.67fg	30.67de	16.53g	16.48e	2.73ef	2.77e
	2 ml/L	47.67f	48.33e	34.67de	34.33c	19.04ef	19.65d	3.24d	3.19d
	3 ml/L	53.33c	53.00c	39.33bc	40.33a	22.04c	22.05c	4.04b	3.98b

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

3- Nutritional status:

Data presented in Table (5) exhibited that spraying snapdragon (*Antirrhinum majus* L.) plants with potassium nitrate (KNO_3) at 3 g/l increased leaf N% which recorded the highest values (2.65 and 2.67%) followed by KNO_3 at 2 g/l compared to the other treatments in both seasons, respectively, while leaf P % was not affected by treatments in both seasons. Concerning leaf K % the obtained data confirmed that, spraying plants with potassium sulphate at 3 g/l and potassium silicate at 3 g/l significantly increased leaf K % without significant differences in between followed by potassium nitrate treatment at 3 g/l comparing with the lowest values obtained by control and potassium silicate at 1 g/l while, the other treatments gave intermediate values. However, plants sprayed with potassium silicate gave the highest leaf Si content compared with the other treatments especially for plants treated with potassium silicate at 3 ml/l which recorded the highest values (1.02 and 1.23 ppm) comparing with the lowest values (0.44 and 0.43 ppm) obtained with control in both seasons, respectively. The present results are in harmony with the findings of El-Attar (2017), Verma *et al.*, (2019) on snapdragon, Kumar and Mishra (2002) on gladiolus and Abd El Gayed(2019) on Zinnia plants.

Table 5. Effect of foliar application different potassium forms on nutritional status of snapdragon *(Antirrhinum majus* L.) plants during 2018 and 2019 seasons

Treatments		Nutritional status							
		N (%)		P (%)		K (%)		Si (ppm)	
		2018	2019	2018	2019	2018	2019	2018	2019
Control		1.74d	1.75d	0.276a	0.277a	1.27d	1.32d	0.44d	0.43e
Potassium sulphate (K_2SO_4)	1 g/L	1.76d	1.78d	0.280a	0.283a	1.47bc	1.48bc	0.49d	0.52d
	2 g/L	1.75d	1.76d	0.282a	0.278a	1.50bc	1.53ab	0.50d	0.52d
	3 g/L	1.77d	1.78d	0.2786a	0.277a	1.59a	1.60a	0.50d	0.50d
Potassium nitrate (KNO_3)	1 g/L	1.95c	1.99c	0.278a	0.278a	1.42c	1.44c	0.51d	0.50d
	2 g/L	2.13b	2.23b	0.273a	0.281a	1.49bc	1.51bc	0.52d	0.50d
	3 g/L	2.65a	2.67a	0.281a	0.281a	1.54ab	1.55ab	0.49d	0.50d
Potassium silicate (K_2SiO_3)	1 ml/L	1.70d	1.71d	0.279a	0.280a	1.35d	1.35d	0.67c	0.70c
	2 ml/L	1.70d	1.71d	0.280a	0.280a	1.44c	1.45c	0.77b	0.80b
	3 ml/L	1.74d	1.74d	0.277a	0.279a	1.58a	1.60a	1.02a	1.23a

Means within a column having the same letters are not significantly differences according to Duncan's multiple range test (DMRT).

CONCLUSION

From the obtained results, it can be concluded that potassium foliar spray can be used as a partial substitution of the recommended soil amended potassium for increasing nutrients uptake and thus stimulating growth and flowering characteristics of *Antirrhinum majus* plants and potassium sulphate at 3 g/l can be used in this respect.

REFERENCES

Abbadi, J.; J. Gerendas and B. Sattelmacher (2008). Effects of potassium supply on growth and yield of safflower as compared to sunflower. Plant Nutrition and Soil Science, 171(2): 272 – 280.

Abd El Gayed, M. E. (2019). Effect of silicon levels and methods of application on vegetative growth and flowering of zinnia (*Zinnia elegans* L.). J. Product. & Dev., 24(4): 929 – 944.

Adams, E. and R. Shin. (2014). Transport, signaling, and homeostasis of potassium and sodium in plants. Journal of Integrative Plant Biology, 56(3):231 – 249.

Ashour, H.A.; S.M. Heider and A.W. Mahmoud (2018). Response of *Euryops pectinatus* L. plants to different types of fertilizers and growth retardants. Middle East Journal of Applied Sciences, 8(2): 492 – 507.

Chapman, H.D. and P.F. Pratt (1978). Methods of Analysis for Soils, Plant and Water. Univ. California USA.

Dai, W.M.; K.Q. Zhang; B.W. Duan; C.X.Sun; K. L. Zheng; R. Cai and J.Y. Zhuag (2005). Rapid determination of silicon content in rice .Rice Sci., 12:145-147.

Dhatt, K.K.; S. Bhandari and T. Thakur (2019). Effect of micronutrients and KNO_3 on vegetative growth, flower yield and pigments of *Tagetes erecta* cv. 'Pusa Narangi'. International Journal of Current Microbiology and Applied Sciences, 8(9): 54 – 61.

Dorgham, A.H. (2019). Vegetative growth, flower quality and seed production of *Zinnia elegans* cultivars in response to foliar application of potassium from different sources. Middle East Journal of Agriculture Research, 8(4):1306 – 1318.

Duncan, B.D. (1955). Multiple range and multiple F-test. Biometrics,. 11:1-42.

El-Attar, A. (2017). Is the performance of snapdragon plants (*Antirrhinum majus* L.) influenced by some bio-stimulators under salinity stress? Journal of Horticultural Science & Ornamental Plants, 9 (2): 52-64.

El-Gamal, S.M.A. (2015). Influence of pinching and potassium sources on growth and flowers yield of *Calendula officinalis.* Egyptian Journal of Horticulture, 42(1): 639 – 654.

El-Naggar, A.H. and A.B. El-Nasharty (2016). Effect of potassium fertilization on growth, flowering, corms production and chemical contents of *Gladiolus hybrida*, L. Cv. "Rose Supreme". Alexandria Science Exchange Journal, 37(4):714 – 728.

El-Sayed, B.A. (2012). Effect of potassium fertilization sources, bulb size and their interactions on growth and flowering of tuberose (*Polianthus tuberosa* L.). Research Journal of Agriculture and Biological Sciences, 8(2):250 – 255.

Hamayl, A.F.; M.M. EL-Saka; E.A.H. El-Boraie and A.E.A. Gad (2016). Effect of potassium sulfate and calcium borate on improving quality and production of Dahlia flowers. J. Plant Production, Mansoura Univ., 7(12):1281 – 1286.

Hammond, J.P. and P.J. White (2008). Sucrose transport in the phloem: integrating root responses to phosphorus starvation. Journal of Experimental Botany, 59(1): 93 – 109.

Hasanuzzaman, M.; M. H. Bhuyan; K. Nahar; S. Hossain; J. Al Mahmud; S. Hossen; A.A. Masud; A.C. Moumita and M. Fujita (2018). Potassium: A vital regulator of plant responses and tolerance to abiotic stresses. Agronomy 8: 31; doi: 10.3390/ agronomy 8030031

Hashem, H.A. (2016). Effect of sowing date and fertilization treatments on growth and chemical constituents of *Calendula officinalis* plants under North Sinai conditions. Middle East Journal of Agriculture Research, 5(4): 761 – 774.

Heikal, A.A.M. (2017). The influence of foliar application of biostimulant atonik and different sources of potassium on full sun and partial shade *Salvia farinacea* plants. Egyptian Journal of Horticulture, 44(1): 105 – 117.

Jackson, M.L. (1967). Soil Chemical and Plant Analysis. Prentice Hall of India, New Delhi.

Karley, A.J. and P.J. White (2009). Moving cationic minerals to edible tissues: potassium, magnesium, calcium. Current Opinion Plant Biology, 12(3): 291 – 298.

Kumar, R. and R.L. Mishra (2002). Response of gladiolus to nitrogen, phosphorous and potassium fertilization. Journal of Ornamental Horticulture, 6(2): 95-99.

Malik, S.A.; H.A. Neelofar; Z.A. Qadri; I.T. Nazki; S.A. Mir; F.A. Khan and M.S. Pukhta (2019). Effect of gibberellic acid, spacing and nutrient sprays on growth and flowering in snapdragon (*Antirrhinum majus* L.) cv. Rocket Pink. International Journal of Plant & Soil Science, 28(1): 1 – 6.

Mjeed, A.J. and Ali M.A. (2017). Effect of gyttia and nitrogen applications on growth and flowering of snapdragon plants in two soil depths. Kurdistan Journal for Applied Research, 2(1). P-ISSN: 2411-7684- E-ISSN: 2411-7706.

Murphy, J. and J.D. Riely (1962). A modified single solution method for the determination of phosphate in natural water. Anal. Chem. Acta, 27: 31-36.

Netto, A.T.; E. Campostrini., J.G. Oliveira and R.E. Bressan-Smith (2005). Photosynthetic pigments, nitrogen, chlorophyll a florescence and SPAD readings in coffee leaves. Scientia Hort., 104: 199 – 209.

Pal, P. and P. Ghosh (2010). Effect of different sources and levels of potassium on growth, flowering and yield of African marigold (*Tagetes erecta* Linn.) cv. Siracole. Indian Journal of Natural Product and Resources, 1(3): 371 – 375.

Romheld, V. and E.A. Kirkby (2010). Research on potassium in agriculture: needs and prospects. Plant Soil, 335(1-2): 155 – 180.

Shah, M.S.; M. Qquresh; S. Chughta; K. M. Quresh and I.A. Hafiz (2018). Comparison of impact induced by different priming techniques on germination and plant development in lisianthus (*Eustoma grandiflorum*). Pak. J. Bot., 50(6): 2159 – 2165.

Shin, R. (2014). Strategies for improving potassium use efficiency in plants. Molecules Cells, 37(8): 575 – 584.

Shyala, M.R.; D. Dhanasekaran and S. Rameshkumar (2019). Effect of foliar application of micronutrients and potassium humate on growth and flower yield of African marigold (*Tagetes erecta* L.). Annals of Plant and Soil Research, 21(2): 101 – 107.

Snedecor, G.W. and W.G. Cochran (1990).Statistical Methods. 7th Ed. Iowa State Univ. Press. Ames., Iowa, USA, 593pp.

Sustr, M.; A. Soukup and E. Tylova (2019). Potassium in root growth and development. Plants (Basel) 8(10):435; https://doi.org/10.3390/plants8100435

Tolety, J. and A. Sane (2011). "Antirrhinum." In Wild Crop Relatives: Genomic and Breeding Resources, Plantation and Ornamental Crops, C. Kole (Ed.), Chapter one, P: 1 - 14. Springer-Verlag Berlin Heidelberg.

Verma, S.; A. Kumar and A.K. Dwivedi (2019). Studies on effect of nitrogen and phosphorus on the performance of snapdragon (*Antirrhinum majus* L.): A review. Journal of Pharmacognosy and Phytochemistry, 8(4): 2571 – 2575.

Wang, M.; Q. Zheng; Q. Shen and S. Guo (2013). The critical role of potassium in plant stress response. International Journal of Molecular Sciences, 14(4): 7370 – 7390.

Yassen, A.A.; A.M Habib;.; S.M. Zaghloul and S.M. Khaled (2010). Effect of different sources of potassium fertilizers on growth yield, and chemical composition of Calendula Officinalis. Journal of American Science, 6(12): 1044 – 1048.

Zaman, U.; Ahmad, Z.; Farooq, M.; Saeed, S.; Ahmad, M. and A. Wakeel (2015). Potassium fertilization may improve stem strength and yield of basmati rice grown on nitrogen –fertilized soils. Pakistan J. Agric., 52(2): 437 – 443.

Zorb, C., M. Senbayram and E. Peiter (2014). Potassium in agriculture-status and perspectives. Journal of Plant Physiology, 171(9):656 – 669.

تأثير الرش بصور مختلفة من البوتاسيوم على نمو وإزهار نباتات حنك السبع

محمد السيد عبد الجيد[1]* و رمضان إسماعيل كنانى[2]

[1] قسم بحوث الحدائق النباتية - معهد بحوث البساتين - مركز البحوث الزراعية- الجيزة- مصر

[2] قسم بحوث تغذية النباتات - معهد بحوث الأراضى والمياة والبيئة - مركز البحوث الزراعية- الجيزة- مصر

أجريت تجربة أصص خلال موسمي 2018 و 2019 بمحطة بحوث البساتين بسخا ، محافظة كفر الشيخ ، مصر و ذلك لدراسة تأثير الرش بكبريتات البوتاسيوم 50% ونترات البوتاسيوم 43% بمعدلات 1 ، 2 ، 3 جم / لتر ماء وسيليكات البوتاسيوم 38% بمعدل 1 و 2 و 3 مل / لتر ماء على نمو وازهار والحالة الغذائية لنباتات حنك السبع . أشارت النتائج إلى أن الرش الورقي بمعاملات البوتاسيوم المختلفة أثر معنوياً على جميع الصفات تحت الدراسة مثل طول النبات ، عدد الافرع على للنبات ، الوزن الرطب والجاف للنبات ، الجذور والأزهار ، عدد الأزهار /النبات ، ارتفاع الحامل الزهرى على النبات و محتوى الكلوروفيل والحالة الغذائية (النيتروجين والفوسفور والبوتاسيوم والسيليكون) وذلك عند المقارنة بالكنترول. أعطى الرش الورقي بكبريتات البوتاسيوم بمعدل 3 جم / لتر ماء أعلى قيم معنوية لطول النبات ، وعدد الأفرع ، والوزن الرطب والجاف ، والجذور والأزهار ، وعدد الأزهار / نبات ، وارتفاع الحامل الزهري ، والكلوروفيل الكلي مقارنة بالمعاملات الأخرى. . كما أظهرت النتائج زيادة معنوية في صفات النمو وخصائص التزهير والحالة الغذائية (النيتروجين والبوتاسيوم والسيليكون) مع زيادة مستويات البوتاسيوم من 1 إلى 3 جم / لتر ماء أو مل / لتر ماء تحت نفس مصدر البوتاسيوم. لذلك ، يمكن الاستنتاج أنه يمكن استخدام رش البوتاسيوم الورقي كبديل جزئي للبوتاسيوم الموصى به في التربة لزيادة امتصاص العناصر الغذائية وبالتالي تحفيز النمو وخصائص الإزهار لنباتات حنك السبع و افضل معاملة تحت ظروف البحث هى الرش بكبريتات البوتاسيوم عند 3 جم / لتر ماء.