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The Impact of Drought Stress of the Cultivation Medium on the Growth and Postharvest Life of *Lilium* and Chlorophyll in Different Potassium Concentrations of Nutrient Solution

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Abstract

To study the effect of different concentrations of potassium in the nutrient solution and water stress on the quality and quantity yield of *Lilium* LA cv.*Termoli*, a pot experiment was conducted based on completely randomized design in sand and perlite medium (50:50) in three levels of potassium (K-free, 6 mM K and and 12 mM K in Hoagland solution) with three replications. In the present study, the growth indices, post-harvest life of flower and potassium and chlorophyll contents were measured in shoots. The results showed that the plant dry/fresh weight and vegetative height was highest in 6 mM potassium treatments. Lily postharvest life at 6 mM K was increased 5.7 days relative to k-free conditions. The chlorophyll a, b and total content in nutrient solution without K were lower than in nutrient solution with 6 and 12 mM potassium.

Keywords: Chlorophyll, Growth medium, Perlite, Postharvest life.

INTRODUCTION

Among the various kinds of bulbous plants, *Lilium* is uniquely beautiful flowers that its colorful plants favor high price and is grown as cut flowers or pot (Sajid *et al*., 2009). This plant is ranked fourth followed by rose, carnation and chrysanthemums. Every year, this plant in Netherland flower auction market is sale about 150 million cut (Burchi *et al.*, 2010). One of the most important factors affecting the quality of the flowers is appropriate nutrition. Nutrients supply affects on plant growth and metabolism. Nutritional studies on bulbous flowers are difficult, because the nutrients are in storage form in the bulb. So to overcome nutritional problems mentioned above, cultivation experiments on mediums without nutrients along with nutrient solution are recommended (Naseri and Ibrahimi, 2002). Potassium has considerable importance in *Lilium* nutrient. This element lead to optimal improves in plant growth and increases flowers post harvesting life because of the role in the protein synthesis process, neutralizing anions and adjusting osmotic potential (Pardo *et al.*, 2006). This element play a role in protein synthesis, photosynthesis and transport materials from its. In the case of potassium deficiency, the activity of some enzymes, uptake and transport of some nutrients will reduce (Kanai *et al.*, 2007). Morgan (1992) and Ma *et al.* (2004) reported that lines of rapeseed and mustard that showed high osmotic adjustment had high concentration of potassium in their tissues.

Potassium ions catalyze the transfer of materials from photosynthesis. This is probably related to photophosphorylation processes. Increasing photophosphorylation and photosynthetic electron transport in plants having sufficient good potassium ions is observed. Photosynthetic electron transport system is the major source of reactive oxygen production in plant tissues (Asada, 1994) that have the potential to produce single oxygen and superoxide. The present study was designed to investigate the effect of different concentrations of potassium in nutrient solution under conditions of drought stress on yield of lily.

MATERIALS AND METHODS

Premature bulbs of lilium LA hybrid cv.'Termoli' were prepared and were transferred to the Islamic Azad University, Science and Research Branch, Guilan, Iran. A completely randomized design with three treatments in three replicates in a medium sand and perlite (50:50) was designed. The medium moisture and water-holding capacity condition was always faced dry between two irrigations. Treatments were consisted of three levels of zero (nutrient solution without potassium), 6 mM potassium and 12 mM potassium in Hoagland solution.

Perlite with a diameter of 1 to 2 mm (fine) was used and several times washed with double distilled water for reduce fluoride. River sand was washed several times to be free of any mud and then packed in cellophane bags and were disinfected using an autoclave (120°C for 15 min). Lily bulbs incubated with 10g Benomyl fungicide solution in ten liters of water for 15 minutes before planting. And then, were placed on paper without rinsing and were completely dried by air flow. Pots made with a height of 15 cm and two liters volume were disinfected with sodium hypochlorite 1%. Bulbs was planted after disinfect inside the pot with a depth of 10 cm and then were placed in a greenhouse spacing 20×20 cm and irrigated with 300 mL of deionized water immediately for each pot. Average, minimum and maximum temperatures during the growing period were measured by the thermometer that was 18-22 and 17-16°C at day and night, respectively.

Hoagland solution was used in the experiment (Hoagland, 1950). Salts present in the Hoagland formula are including potassium phosphate, potassium nitrate, calcium nitrate and magnesium sulfate which containing six elements of phosphorus, potassium, nitrogen, calcium, sulfur and magnesium. Then, a molar solution of each of them was prepared as a mother or stock solutions. Applying a certain amount of each salt stock solution, sufficient amount of needed nutrients is provided. However, to control or change one or more nutrient concentrations, concentrations of other elements in the formula will change. Due to changes in potassium concentration in the nutrient solution (in standard mode, 6 mmol), potassium nitrate in K-free condition is not intake.

Table 1. The salts applied in preparation of nutrient solution in three concentrations of potassium.

Macronutrients			Micronutrients
12 mM K	**6 mM K**	**Without potassium**	
KH_2PO_4 KNO_3 $Ca(NO_3)_2{,}_4H^2O$ $MgSO_4{,}7H^2O$ K_2SO_4	KH_2PO_4 KNO_3 $Ca(NO_3)_2{,}_4H_2O$ $MgSO_4{,}7H_2O$	H_3PO_4 $Ca(NO_3)_2{,}_4H_2O$ $MgSO_4{,}7H_2O$ NH_4NO_3	H_3BO_3 $MnCl_2.{}_4H_2O$ $ZnSO_4.{}_7H_2O$ $CuSO_4.{}_5H_2O$ $H_2MoO_4.H_2O$ $Fe_2(C_4H_4O_6)_3$

Control: 2 peat +1 perlite in volume rate; PSC: peanut shells compost

Decrease in the amount of nitrogen in the nutrient solution due to decreased intake of calcium nitrate compensated from ammonium nitrate salt. The main reason for the use of ammonium nitrate is to supply nitrogen both in nitrate (NO_3^-) and ammonium (NH_4^+). Increase in potassium concentration in the nutrient solution at a concentration of 12 mM is supplied through potassium sulfate. Potassium salts used in any concentration can be seen in Table 1.

The nutrient solution system was an open system and nutrient solution with irrigation water (300 mL) was used once every three days. The status to maintain moisture in sand and perlite medium was in such a way that medium was encountered with drought and the plant faced with drought stress during both irrigations. To measure the flowering time, the number of days from bulbs planted in pots to the first appearance of bud was counted. Lilies stem end height, stem diameter, reproductive height (distance between the lowest pedicel to tip of the longest bud), and shoot dry weight were measured. To measure the durability of the cut flowers, cut flowers are placed in water and the number of days from harvesting cut flowers until when 50% of petals falling from each sample, were counted.

To measure potassium, 0.3 g dried sample in oven with 2.3 mL mixture of sulfuric and salicylic acids were soaked for 24 hours. Then, the samples were heated to 180 °C and the solution was colorless adding intermittent and low hydrogen peroxide. Then the solution is brought to the related volume with distilled water and filtered (Emami, 1996).

Chlorophyll content was determined using Arnon (1949) method. To measure chlorophyll content, 0.5 g of green leaves in liquid nitrogen in a porcelain mortar in ice container without light with 0.5 g magnesium carbonate was ground and gradually adds about 10 ml of acetone 80%. One ml of the prepared extract after centrifugation was placed in a spectrophotometer cell and the amount of light absorbed by chlorophylls a and b was read at 645 and 663 nm wavelengths, respectively. The amount of chlorophyll a, b and total were determined by the following formula:

$V/W \times C_{chl.a}$: (0.0127) (oD 663) – (0.000259) (oD 645)

$V/W \times C_{chl.b}$: (0.0229) (oD 645) – (0.000469) (oD 663)

CchlT: (0.0202) (oD 645)-(0.0080) (oD 663) × V/W

Where, C is chlorophyll a, b and total concentration in mg/g leaf fresh weight and oD is the light absorption rate at corresponding wavelengths and V is the acetone 80% volume and W is leaf fresh weight.

RESULTS AND DISCUSSION

Table 2 shows the results of data analysis of variance related to the effect of potassium concentration in nutrient solution on plant growth indices. Effect of treatments on shoot dry weight, postharvest life, shoots potassium concentrations and the number of secondary buds was significant at 1% and shoot fresh weight, bud coloring time, vegetative and reproductive height, initial number of buds, stem diameter and flower diameter was significant at 5%.

Tables 3-5 show the effect of treatment on the growth indices of lilium. The highest shoot fresh/dry weight is related to 6 mmol of potassium with 16.6 g and 14.1g, respectively. Shoot fresh

Table 2. Variance analysis of data related to the effect of potassium concentration in nutrient solution on plant growth.

Variation Resources	Freedom Degree	Mean Squared					
		Fresh weight of shoot	Dry weight of shoot	Time to appearance flower bud	Buds coloring time	Postharvest life	Potassium Concentration in shoot
K concentration	2	6745.1*	32.0**	45.4^{ns}	532.0*	546.0**	18.7**
Error	16	1750.5	0.37	62.2	135.0	34.4	0.48
		Vegetative height	reproductive height	Primary flower bud number	secondary flower bud number	Flower bud aborted number	First flower bud length
K concentration	2	741.7*	142.2*	4.8*	18.4**	0.9^{ns}	978.2^{ns}
Error	16	185.2	36.2	1.3	1.57	2.2	874.8
		stem diameter	Opened flower diameter	Leaf number	Fresh weight of underground organ	Fresh weight of rooted stem	Dry weight of rooted stem
K concentration	2	5.42*	4521.6*	100.0^{ns}	20.8^{ns}	24.9^{ns}	1.4^{ns}
Error	16	1.37	987.2	97.4	287.2	23.5	1.80

weight in 12 mM potassium showed significant reduction compared with the control, and the 6 mM potassium. It seems that in 6 mM potassium, potassium had been adequately and plants with potassium stock lost less water. As a result, water conservation increased shoot fresh weight. Sulter (1957), Tisdale *et al*. (1985) and Huber (1985) also stated that, due to its role in the growth and development of plant cells and making cell turgor and opening and closing of stomata, potassium maintain water in plant and this has greatly increased plant fresh weight.

It seems that shoot fresh weight reduction in treatment 12 mM potassium than 6 mmol is due to an antagonistic effect of these element and other nutrients. Bould (1964) stated that increase potassium levels in the nutrient solution due to antagonist's effect of potassium with magnesium and calcium reduced their uptake by the plant. These findings are corresponded to Barra-aguilar *et al*. (2012) in lily and Wang (2007) in the orchid flowers.

There is no significant difference between the time of bud coloring in K-free and 6 mM potassium medium (Table 3). Double increasing the potassium reduce bud coloring time. The results are corresponded to Wang (2007) on the orchid flowers. Stem diameter in 12 mM potassium treatments was significantly decreased compared to K-free treatment (Table 4). According to the results of Table 5, the reduction in diameter of open flowers was found in 12 mM potassium con-

Table 3. The effect of treatment on Fresh and dry weight of shoot, vegetative and reproductive height, time to appearance flower bud and buds coloring time.

K concentration in nutrient solution	Fresh weight of shoot (g)	Dry weight of shoot (g)	Vegetative height (cm)	Reproductive height (cm)	Time to appearance flower bud (day)	Buds coloring time (day)
Without K	121.3^{c}	9.9^{c}	86.9^{b}	9.2^{b}	28.2	42.8^{a}
6 mM	158.3^{a}	15.4^{a}	98.5^{a}	9.5^{b}	26.7	43.0^{a}
12 mM	133.0^{b}	13.0^{b}	94.0^{a}	11.0^{a}	28.2	30.2^{b}

Table 4. The effect of treatment on first flower bud length, leaf number, bud number and stem diameter.

K concentration in nutrient solution	First flower bud length (mm)	Leaf number	Primary flower bud number	Secondary flower bud number	Flower bud aborted number	Stem diameter (mm)
Without K	59.8	92.9	5.4^{a}	1.6^{a}	0.88	14.6^{a}
6 mM	64.6	90.8	6.0^{a}	2.0^{a}	0.62	15.2^{a}
12 mM	50.4	86.5	4.2^{b}	0.5^{b}	0.67	13.8^{b}

Table 5. The effect of treatment on flower diameter, fresh weight of underground organ and fresh and dry weight of rooted stem.

K concentration in nutrient solution	Opened flower diameter (mm)	Fresh weight of underground organ (g)	Fresh weight of rooted stem (g)	Dry weight of rooted stem (g)
Without K	146.6^{a}	48.4	8.0	1.8
6 mM	134.2^{a}	46.5	7.8	1.4
12 mM	102.8^{b}	48.6	5.6	1.2

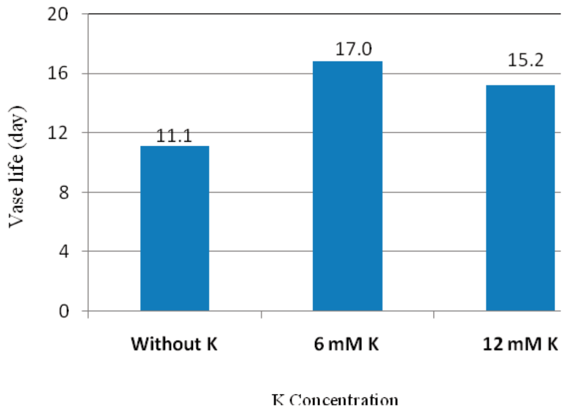

Fig. 1. The effect of K concentration in nutrient solution on postharvest life.

centration compared to without K. It seems in the plant fed with nutrient solution 12 mM potassium, potassium content of the nutrient solution was sufficiently high (luxury consumption). The plants first grew normally, but gradually during plant reproductive development, high concentrations of potassium left its negative effects through agonistic effect on the uptake of other nutrients; especially calcium which is contributes in the increase of cell wall and increase the flower diameter. And thus the diameter of the opened flower in the treatment was decreased. Barrera-Aguilar *et al*. (2012) in study on *Lilium* in Mexico examined the effect of 4 potassium levels (0, 5, 10, 20 mM) in Hoagland solution on *Lilium* growth and photosynthesis grown in acidic peat. The results showed that at concentrations 5 to 10 mM, flower diameter, plant height and plant dry weight was increased; however, higher concentrations of potassium had adverse effect on the listed traits. Wang (2007) examined the impact of different levels of potassium (50, 100, 200, 300, 400, 500 ppm) on the *Phalaenopsis* orchid. The results showed that the largest and tallest inflorescence regardless of the medium was obtained at level of 300 ml/l. The higher amount had an inverse effect on all traits.

Lily postharvest life at a concentration of 6 mM potassium was increased 5.7 days than in the potassium-free conditions (Fig. 1); however there is not found significant difference between postharvest in 12 mM potassium in nutrient solution and potassium-free conditions.

Increase potassium in the nutrient solutions based on the antagonistic action between potassium, magnesium and calcium may decrease the uptake of magnesium and calcium (Bould, 1964).

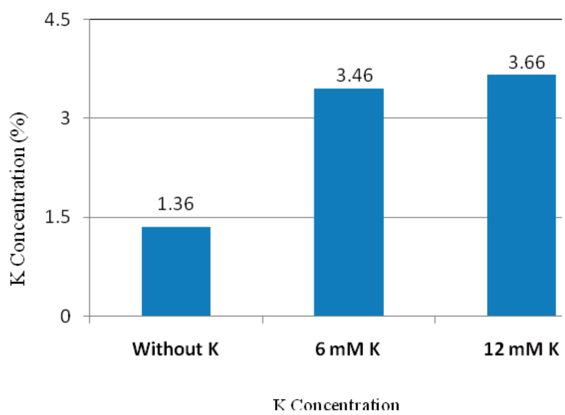

Fig. 2. The effect of K concentration in nutrient solution on K concentration of shoot.

Table 6. The effect of treatment on carotenoid, chlorophyll a, b and total.

K Concentration	Carotenoid	Chlorophyll A	Chlorophyll B	Total Chlorophyll
	(mg/g FW)			
Without K	0.67	1.77 [b]	1.21	2.98 [b]
6 mM K	0.66	1.97 [a]	1.44	3.44 [a]
12 mM K	0.67	1.91 [a]	1.39	3.30 [a]

Another reason for reducing flowers postharvest life in 12 mM potassium than 6 mmol of potassium can be high concentration of potassium in the root environment which prevents the uptake of calcium and magnesium in the plant. It is worth noting that among other elements, calcium and magnesium play the most important role in increasing the postharvest life of cut flowers. The effect of calcium on the lily postharvest longevity (Seyedi *et al.*, 2011), Robichuax (2008) in poinsettia and Sosanan (2007) in sunflower has been reported. Probably the reason for no significant difference in the lily postharvest in 12 mM potassium with potassium-free is that lilies are bulbous plants and nutrients stored in its bulb (Naseri and Ebrahim, 2002). According to the results in Fig. 2, the increase of nutrient solution potassium increased in potassium concentrations in shoots. This increase was more than twice the concentration of potassium in potassium-free nutrient solution. This is due to the greater supply of potassium by nutrient solution and more potassium uptake by the plant. Increasing potassium uptake can be a reason in the increase of vase life.

The results in Table 6 show that chlorophyll a, b and total chlorophyll content in nutrient solution without K was lower than in nutrient solutions 6 and 12 mM potassium. It seems that, as a non-organic osmolit in osmotic adjustment, potassium has been effective to reduce the negative effects of drought stress (Ma *et al.*, 2004 and 2006) and consequently to improve metabolic processes including forming chlorophyll. Potassium is involved in the synthesis of chlorophyll pigment precursor (Kumar and Kumar, 2008). This element play a role in protein synthesis, photosynthesis and transport materials from its. In the case of potassium deficiency, the activity of some enzymes, uptake and transport of some nutrients will reduce (Kanai *et al.*, 2007).

CONCLUSION

Results showed that the plant fresh and dry weight and plant vegetative height in the treatments 6 mM potassium was highest. Lily postharvest at a concentration of 6 mM potassium was increased 5.7 days relative to k-free condition. The amount of chlorophyll a, b and total in the nutrient solution k-free was lower than in the nutrient solution with 6 and 12 mM potassium.

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