AHS
Advances in Horticultural Science

Effect of different nutrient solution and irrigation regimes on growth of Lily (*LA Hybrid 'Fangio'*)

Z.S.N. Mohajer [1], M.H. Asil [1 (*)], J.-A. Olfati [1], M.R. Kaledian [2]

[1] *Department of Horticultural, Faculty of Agricultural Sciences, Guilan University, Rasht, Iran.*

[2] *Department of Water Engineering, Faculty of Agricultural Sciences, Guilan University, Rasht, Iran.*

Key words: nutrition, soilless culture, vase life, water consumption.

(*) **Corresponding author:**
asilhassanpour@yahoo.com

Citation:
MOHAJER Z.S.N., ASIL M.H., OLFATI J.-A., KALEDIAN M.R., 2019 - *Effect of different nutrient solution and irrigation regimes on growth of Lily (LA Hybrid 'Fangio').* - Adv. Hort. Sci., 33(4): 529-535.

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no competing interests.

Received for publication 2 August 2019
Accepted for publication 30 August 2019

Abstract: A better understanding of the effects of nutrients element and irrigation levels on production of Lily (*Lilium* LA Hybrid *Fangio*) can lead to optimal uses of nutrients and water. Plant growth is strongly correlated with the amount of irrigation and fertilization. In this regard, a greenhouse experiment was carried out to evaluate the effect of different nutrient solution viz. high concentration of elements (S1), medium concentration of elements (S2), and high concentration of elements (S3) under different irrigation regimes (100, 90, 80 and 70 % of field capacity (FC) in soilless culture. In well-watered treatments (100% FC), S3 enhanced the vase life by 17% compared to S1. The maximum leaf number was observed in the interaction of S3 and 90% FC, whereas its minimum was found in the interaction of S1 and 70% FC. Under 70% FC, S3 increased the leaf length by 6% in comparison with S1. Leaf width was altered by simultaneous use of nutrient solution and irrigation, ranging from S2 and 80% FC (13.3 mm) to S1 and 70% FC (9 mm). In S3, 70% FC decreased the bud length by 9% relative to 100% FC. The days until flowering varied from the interaction of S2 and 70% FC (4.1 days) to S1 and 100% FC (6 days). Under S1 treatments, 70% FC decreased the flower number by 18% compared to 100% FC. The highest weight of daughter bulb was observed in interaction of S2 and 80% FC. In contrast, the lowest weight of daughter bulb was found in S2 and 90% FC.

1. Introduction

Lilies have become economically important, mainly because of beautiful, large, attractive and fascinating form of flowers, long vase life and capacity to rehydrate after long transportation. Bulbs are produced commercially for use in the cut flower and potted plant industries (Aslam *et al*., 2013; Al-Allaq *et al*., 2014). The importance of this genus in the world flower market is due to the existence of a wide variety of hybrids and numerous commercial cultivars (Dhyani *et al*., 2009).

In recent decades, supplying the nutrient solution to plants in order to optimize crop nutrition has been widely used in both soil and soilless culture under greenhouse conditions (Savvas *et a*l., 2013). Nutrient solution management can provide a sustainable and effective schedule in floriculture by applying different horticultural practices such as water use efficiency. It has been estimated that 100-350 L of water are needed to produce 1 kg of plant dry matter, and this may vary with species and variety, cultivation system and plant growing season (Cassaniti *et al*., 2012). The lack of dependable supplies of good quality water in many regions of the world has become a concern among agricultural, urban, industrial and environmental components (Valdez-Aguilar *et al*., 2009). Optimal irrigation scheduling could lead to higher water use efficiency. It is also very important since it influences the rhizosphere environment, media water potential, and salt accumulation, which in turn affects plant growth, photosynthesis and consequently crop production and quality (Tsirogiannis, 2010). Appropriate use of water supply and nutrients results in better water use efficiency, stressful situations, and control production (Raviv and Blom., 2001). Since in soilless culture systems the water is generally distributed in excess, and consequently the nutrients are removed from the substrate by drainage water and accumulate in the recirculating nutrient solution, which has to be flushed out regularly, representing the negative environmental impacts (Rouphael and Colla., 2009; Wortman, 2015). In bulbous ornamental plants, the flower production and bulb yield are remarkably important in their profitability (De Vroomen, 1993; Maroyi, 2016). An accurate schedule on nutrients and water supplies may decrease production costs and the risk of water pollution (Dufour and Guérin., 2005). Hence, it is essential to have a good knowledge of the plant's mineral requirements in order to avoid nutrient waste. On the other hand, it is necessary to limit mineral imbalance in the medium by assuring a minimal leaching of excess nutrient solution (Chang *et al*., 2010).

Recently, some nutritional solution formulas and irrigation levels have been used to increase the production efficiency, which the suitability of these treatments should be considered with appropriate levels of nutrients and irrigation (Grewal and Maheshwari, 2011; Waraich *et al.*, 2011; Grzebisz *et al.*, 2013; Quaggio *et al.*, 2019). The intent of these studies was to develop the optimal irrigation and nutrient systems that could meet the high productivity of plants with explaining different levels of nutrients and water supply. To our knowledge, there is no published document on the water use and nutrients application on the growth of lily. Therefore, the purpose of present study was to assess the simultaneous application of different irrigation regimes and nutrient solutions on growth of lily (*Lilium* LA sp. cv. *Fangio*).

2. Materials and Methods

Plant material and growing conditions

The experiment was carried out during 2016-2017, under greenhouse conditions at the research unit greenhouse of Islamic Azad University, Gorgan, Iran, for three months. Inside the greenhouse, ventilation was provided automatically when the air temperature exceeded 26˚C. Average day and night temperature were 25˚C and 14˚C, respectively, and average maximum and minimum relative humidity was 70% and 50%, respectively. Uniform sized bulbs of LA Lilium (*Lilium* LA. Hybrid) cv. '*Fangio*' were obtained from a commercial importer (circumference 18-20 cm) and was immersed in a fungicide drench for 10 seconds. The bulbs were cultured in the medium containing cocopeat and perlite (2:1) with EC of 2.95 dS m^{-1}, pH of 5.9, and bulk density of 0.17 g cm^{-3}. The bulbs were cultured in the plastic pots (15 cm height, 17 cm diameter, and 3 liters) on September 2016.

Nutrient solution and irrigation regimes

The study was designed as factorial based on completely randomized design (CRD) with three levels of nutrient solution and four levels of irrigation in six replications. The nutritional solutions contained a low concentration of elements (S1), medium concentration of elements (S2) and high concentration of elements (S3). The nutrient solutions were prepared based on modified Quick nutrient solution (Olfati, 2015). All chemical substrate (solution or elements) used in the study were purchased from Merk (Darmstadt, Germany). Water regimes were applied at 100, 90, 80 and 70% field capacity (FC). It was conducted based on weighing method as 200 ml for well-watered treatment (100% FC) followed by 180, 160, and 140 ml for 90, 80 and 70% FC, respectively. The nutrient solutions used in the experiment are shown in Table 1. The concentrations of ions in the irrigation water were expressed as mgL^{-1} (Table 1). Micronutrients were added to the plants as iron chelate (EDDHA) (0.075 ppm), manganese sulfate 0.001, zinc sulfate 0/01, copper sulfate 0.03, EDTA molybdenum 0.001, and boric acid (H_3BO_4) (0.02 percent. Two weeks after culturing the bulbs (when the bulbs grew in 10 cm), feeding was carried out manually according to the plant's water requirement.

Growth parameters

At the end of experiment, the bud length, leaf length, leaf width, number of leaves, plant height, number of flowers, time of flowering, number and size of daughter bulb were measured. Flowers were harvested when the first flower in plants was bloomed. Subsequently, vase life was determined. The vase life of individual flowers in an inflorescence was evaluated according to their appearance as the number of days since bud opening till the appearance of deformation because of petal wilting. The vase life of the inflorescence was determined as the number of days from the beginning of the experiment up to the fading of the second flower. The end of vase life was determined by flower wilting, tepal abscission or color change in tepals, while in case of leaves, by color fading of blade, yellowing or dying on 30% of the leaf surface.

Statistical analysis

The data (*n*=6) were subjected to one-way analysis of variance (ANOVA) and using the SAS software package for windows (SAS, version 9.3, SAS Institute, Cary, NC). When statistical significance ($p<0.05$) was detected, the mean values subjected to Duncan's multiple range tests.

3. Results

Vase life and plant height

Vase life of lily was affected by nutrient solution ($P \leq 0.05$, Table 2). In well-watered treatments (100% FC), S3 enhanced the vase life by 17% compared to S1 (Table 3). Plant height was influenced by the nutrient solution ($P \leq 0.05$, Table 2). Plant height was different between treatments, ranging from 18.8 cm in

Table 1 - The concentration of elements used in the nutritional solution

Nutrient solutions (mg L^{-1})	Potassium nitrate	Dipotassium hydrogen phosphate	Potassium dihydrogen phosphate	Calcium nitrate	Ammonium nitrate	Sodium chloride	Magnesium sulfate	Ec (dS m^{-1})	pH
Nutrient Solution 1 (S1)	631.3	43.5	102	512.5	150	14.6	230.6	1.04	5.8
Nutrient Solution 2 (S2)	757.55	52.2	122.4	615	180	17.5	276.7	2.38	5.4
Nutrient Solution 3 (S3)	883.8	60.9	142.8	717.5	210	20.4	322.8	2.74	5.7

Table 2 - Analysis of variance for the studied traits of lily (*Lilium* LA sp. cv. Fangio)

S.O.V	df	Vase life	Plant height	Leaf number	Leaf length	Leaf width	Days until flowering	Flower number	Bulb number	Bulb length	Bulb width
Nutrient solution (NS)	2	22.87 **	117 **	229.4 **	488 **	35.95 **	4.05 NS	0.29 NS	10.68 NS	263 **	0.96 NS
Irrigation regime (IR)	3	1.03 NS	11.2 NS	240.7 **	235 **	16.52 **	57.27 NS	11.12 **	0.12 NS	326 **	9.14 NS
NS×IR	6	2.13 NS	3.24 NS	137.1 **	64.2 **	2.22 *	38.27 NS	0.81 NS	0.4 NS	27.7 NS	8.58 *
Error	55	2.63	8.2	9.05	8.62	0.83	40.8	0.85	0.77	14.6	3.76
CV		10.24	2.4	3.18	2.93	7.81	8.61	10.56	17.32	3.7	17.81

Table 3 - Effect of nutrient solutions and irrigation regimes on post vase life, plant height, leaf number and size of lily (*Lilium* LA sp. cv. Fangio)

Nutrient solutions	Irrigation regime	Vase life (day)	Plant height (cm)	Leaf number	Leaf length (mm)	Leaf width (mm)
Nutrient solution 1 (S1)	100%	14.6±1.8 c	113.0±2.1 c	92.5±2.5 c	101.5±1.9 de	10.6±1.2 fg
	90%	15.1±1.1 a-c	113.5±3.3 c	90.5±2.4 cd	94.8±3.5 f	11.6±1.1 d-f
	80%	15.0±1.4 a-c	114.8±2.5 bc	93.5±3.6 c	96.1±4.1 f	9.8±0.5 gh
	70%	14.0±1.8 ab	112.8±3.7 c	87.5±1.9 d	90.3±4.2 g	9.0±0.8 h
Nutrient solution 2 (S2)	100%	16.5±1.7 ab	115.5±2.1 a-c	96.6±1.9 b	101.5±1.4 de	11.8±0.8 c-e
	90%	16.1±1.4 ab	116.8±1.9 a-c	94.0±3.2 bc	109.5±5.1 a	12.8±0.7 a-c
	80%	17.0±2.1 a	116.5 ±2.3 a-c	105.0±2.6 a	104.1±2.1 b-d	13.3±0.7 a
	70%	15.6±1.2 a-c	116.3.5±4.1 a-c	90.0±1.9 cd	100.2±2.3 e	11.5±0.8 d-f
Nutrient solution 3 (S3)	100%	17.0±1.4 a	115.8±3.1 a-c	96.8±1.5 b	107.5±2.1 ab	12.1±0.6 b-d
	90%	16.1±1.5 ab	118.8±3.3 a	104.6±2.6 a	105.1±2.3 bc	13.7±0.8 a
	80%	15.8±0.5 a-c	118.8±3.2 a	93.5±2.5 bc	102.8±1.8 c-e	13.1±0.6 ab
	70%	16.8±1.2 a	118.0±3.4 ab	90.1±3.8 cd	96.8±2.7 f	10.8±0.8 e-g

plants supplied with the interactions of S3 and 90% FC as well as S3 and 80% FC to 112.8 cm in plants treated with the interaction of S1 and 70% FC (Table 3).

Leaf number and size

The number, length and width of leaves were significantly changed by nutrient solution, irrigation regimes, and their interaction ($P≤0.01$, Table 2). The maximum leaf number was observed in the interaction of S3 and 90% FC (104.6 leaf), whereas its minimum was found in the interaction of S1 and 70% FC (Table 3). Under 70% FC, S3 increased the leaf length by 6% in comparison with S1 (Table 3). Leaf width was changed by simultaneous application of nutrient solution and irrigation, ranging from S2 and 80% FC (13.3 mm) to S1 and 70% FC (9 mm).

Bud length, days until flowering, and flower number

Bud length was affected by nutrient solution and irrigation regime ($P≤0.01$, Table 4). In plants supplied with S3, 70% FC decreased the bud length by 9% relative to 100% FC (Table 4).The days until flowering was not significantly influenced by nutrient solution and irrigation regimes ($P≥0.05$, Table 2). Under the application of both nutrient solution and irrigation regimes, the days until flowering varied from the interaction of S3 and 70% FC (69.1 days) to S1 and 90% FC (77.8 days) (Table 4). Flower number was significantly affected by irrigation regime ($P≤0.01$, Table 2). Under S1 treatments, 70% FC decreased the flower number by 18% compared to 100% FC (Table 4).

The number and weight of daughter bulbs

Daughter bulb number was not significantly influenced by nutrient solution and irrigation regimes ($P≥0.05$, Table 2). Under the application of both nutrient solution and irrigation regimes, bulb number varied from the interaction of S3 and 100% FC (4.1 bulbs) to S1 and 100% FC (6 bulbs) (Table 4). Daughter bulb weight was affected by the interaction of nutrient solution and irrigation regime ($P≤0.01$, Table 2). The highest weight of bulb was observed in interaction of S2 and 80% FC. In contrast, the lowest weight of daughter bulb was found in S2 and 90% FC (Table 4).

4. Discussion and Conclusions

The results showed that high concentration of the elements (S3) improved the flower and leaf attributes of lily. Treder (2005) reported an improvement of bud length and leaf size under the mixture of multicote and liquid fertilization. The results of morphological parameters such as leaf size, number of leaves per plant, and flower number in our study are supported by Khosa *et al.* (2011), as they observed an increase in growth and flowering with the increasing fertilization level of macronutrients. Also, the results of the previous studies have shown that the height of some cultivars might not be affected by fertilization (Treder, 2003). Therefore, it can be concluded that in different cultivars of the lily, the height and some vegetative growth characteristics are influenced by cultivars (Treder, 2003). Our results are also consistent with Devecchi and Remotti (2003), who studied calla (*Zantedeschia aethiopica*) in which different doses of nitrogen and potassium did not significantly affect the length of the floral stem. Moreover, the results of plant height are well-supported by Treder (2005) as the application of multicote at three levels and water-soluble fertilizer for some cultivars of lily at during the vegetation period did not significantly affect the maximum plant height in 'Acapulco', rela-

Table 4 - Effect of nutrient solutions and irrigation regimes on the flower and bulb properties of lily (*Lilium* LA sp. cv. Fangio)

Nutrient Solutions	Irrigation regime	Bud length (mm)	Days until flowering	Flower number	Bulb number	Bulb weight (gr)
Nutrient Solution 1 (S1)	100%	98.9±2.5 c-e	71.5±6.1 ab	9.50±0.9 a	6.0±0.8 a	10.7±2.4 ab
	90%	101.7±2.7 b-d	77.8±6.5 a	8.16±0.8 bc	5.8±0.6 a	10.1±3.1 ab
	80%	98.4±2.9 c-e	74.6±6.9 ab	9.00±1.1 a-c	5.6±0.7 ab	12.1±2.8 ab
	70%	92.7±2.5 f	72.0±3.9 ab	8.00±0.6 bc	5.5±0.7 a-c	10.4±3.4 ab
Nutrient Solution 2 (S2)	100%	109.1±3.2 a	73.6±5.4 ab	9.16±0.8 ab	5.1±0.8 a-d	11.8±2.1 ab
	90%	105.6±2.5 ab	73.3±4.7 ab	8.83±0.9 a-c	5.1±0.4 a-d	8.3±2.6 b
	80%	103.1±3.5 bc	74.0±4.6 ab	9.66±0.7 a	4.6±0.6 b-d	12.5±1.1 a
	70%	99.2±2.8 c-e	74.6±6.6 ab	7.83±0.9 c	5.1±1.1 a-d	11.7±3.2 ab
Nutrient Solution 3 (S3)	100%	103.7±2.4 bc	76.1±6.8 ab	9.66±0.7 a	4.1±0.6 d	10.9±1.9 ab
	90%	108.9±3.3 a	77.5±5.8 ab	7.83±0.8 c	4.3±0.4 d	11.1±2.1 ab
	80%	103.4±2.8 bc	76.8±4.4 ab	9.50±1.0 a	4.5±0.4 cd	10.1±1.9 ab
	70%	95.2±2.7 ef	69.1±5.1 b	7.83±0.6 c	4.6±0.1 b-d	10.7±2.2 ab

tive to other cultivars of lily. Similar to our results, in *Sandersonia aurantiaca*, the number of flowers was not affected by various nutrient treatments (Bernstein *et al.*, 2011). Also, yield, quantified by the mean number of bud per plant, did not differ between the three nutrient solutions or between the four different levels of irrigation tested. The increase of morphological properties of lily fertilization is due to the significant role of essential element presented in the nutrient solution on plant growth. For example (N), Nitrogen is a major constituent of most important plant substances. N compounds comprise 40% to 50% of the dry matter of protoplasm, and it is a constituent of amino acids, the building blocks of proteins. It is also an essential constituent of chlorophyll. N deficiency most often results in stunted growth, slow growth, and chlorosis. Potassium (P) regulates the opening and closing of the stomata by a potassium ion pump, which has a significant role on leaf and flower growth. Additionally the outstanding role of magnesium in plant nutrition is as a constituent of the chlorophyll molecule (Vatansever *et al.*, 2017). Vegetative characteristics of plants are subjective to genetic and environmental factors coupled with optimum fertilizer application and water use method (Lucidos *et al.*, 2013). Marin *et al.* (2011) investigated that the effect of nitrogen, potassium, calcium mixture solutions on Lilium plants, they founded that application of three elements, significantly affected the vegetative growth of *Lilium cv. 'Navona'*expressed as leaf area. Moreover, in this regard, the results of the present study are in accordance with the results of Younis *et al.* (2014) and Asker (2015). The other investigation indicated that the existence of macronutrients enhances the vegetative growth of plants and flowering as N increases (Imran and Gurmani, 2011).

Our results showed that there is no significant change among 100, 90, and 80% FC. However, 70% FC showed a reduction of leaf size, bud number, and days until flowering. Welsh *et al.* (1991) reported that *Photina* × *fraseri* irrigated with 100%, 75%, and 50% represented no different difference in shoot extension and average leaf area. Groves *et al.* (1998) reported similar results with a 40% reduction in irrigation volume resulting in the production of 90% dry weight of C. *dammeri* 'Skogholm'. Also, Rouphael *et al.* (2008) reported that the highest leaf area, and quality index were recorded in irrigation type, using half and full nutrient solution concentration. In another work, the strong correlation of leaf area with high K concentration in the nutrient solution was reported, which is probably due to K role in water relations, turgor maintenance, and cell expansion (Mengel and Kirkby, 2001). Thus, an ample supply of K is recommended for leaf development, which will contribute to plant quality since the foliage is considered an important quality factor to Lilium (McKenzie, 1989). Thus, Lilium can be considered as a species that is compatible with a wide range of nutrient concentrations. Nitrogen is an essential component of chlorophyll, in this connection, the nitrogen content of leaf correlates positively with the leaf chlorophyll content (Loh *et al.*, 2002). Kang *et al.* (2016) showed that an increase in fertilization can reduce the severity of chlorosis in pansy. They pointed out that leaf chlorophyll concentration increased asymptotically with fertilization rate, which finally increase the leaf size and plant height.

In order to reducing over watering, we investigated the water use efficiency and nutrient elements in different nutrient solution and irrigation regimes to ensure adequate water for plants during the growth periods. Outcomes of the present study indicated that Lilium LA Hybrid '*Fangio'* can be properly grown in medium levels of irrigation with no significant change in its morphological properties. 70% FC slightly changed the plant growth particularly leaf size and bud length. Hence, to optimum use of water, we can reduce the water amount to 80% FC even 70% with high use of nutrients concentration.

References

AL-ALLAQ H., ALI H., HAZZIM Y., 2014 - *Hybrid lilies under bulb removal stress*. - Agri. Research, 8: 631-637.

ASKER H.M., 2015 - *Hydroponic technology for lily flowers and bulbs production using rain water and some common nutrient solutions*. - Afr. J. Biotechnol., 14(29): 2307-2313.

ASLAM F., NAZ S., TARIQ A., ILYAS S., SHAHZAD K., 2013 - *Rapid multiplication of ornamental bulbous plants of* Lilium orientalis *and* Lilium Longiflorum. - J. Botany., 45(6): 2051-2055.

BERNSTEIN N., IOFFE M., LURIA G., BRUNER M., NISHRI Y., PHILOSOPH-HADAS S., SALIM S., DORI I., MATAN E., 2011 - *Effects of K and N nutrition on function and production of* Ranunculus asiaticus *pedosphere*. - Soil. Sci. Soc. China, 21(3): 288-301.

CASSANITI C., ROMANO D., FLOWERS T.J., 2012 - *The response of ornamental plants to saline irrigation water,* pp. 131-158. - In: GARCIA-GARIZABAL I., and R. ABRAHAO (eds.) *Irrigation. Water management, pollution and alternative strategies*. Intech Europe, Rijeka, Croatia, pp. 234.

CHANG K.H., WU R., CHUANG K., HSIEH T.F., CHUNG R.S., 2010 - *Effects of chemical and organic fertilizers on the growth, flower quality and nutrient uptake of* Anthurium andreanum*, cultivated for cut flower production*. - Sci. Hort., 125: 434-441.

DE VROOMEN C.O.N., 1993 - *Economics of flower bulb production and forcing*, pp. 171-184. - In: DE HERTOGH A., and M. LE NARD. (eds.) *The physiology of flower bulbs: A comprehensive treatise on the physiology and utilization of ornamental flowering bulbous and tuberous plants.* Elsevier, Amsterdam, The Netherlands, pp. 811.

DEVECCHI M., REMOTTI D., 2003 - *Influence of fertilization on vegetative growth and flowering of the calla (*Zantedeschia aethiopica *Spreng).* - Acta. Horticulturae, 614: 541-545.

DHYANI A., BAHUGUNA Y.M., SENWAL D.P., NAUTIYAL B.P., NAUTIYAL M.C., 2009 - *Anatomical features of* Lilium polyphyllum *D. Don ex Royle (Liliaceae)*. - Am. J. Sci., 5(5): 85-90.

DUFOUR L., GUERIN V., 2005 - *Nutrient solution effects on the development and yield of* Anthurium andreanum *Lind. in tropical soilless conditions*. - Sci. Hortic., 105(2): 269-282.

GREWAL H.S., MAHESHWARI B.L., 2011 - *Magnetic treatment of irrigation water and snow pea and chickpea seeds enhances early growth and nutrient contents of seedlings*. - Bioelectromagnetics, 32(1): 58-65.

GROVES K.M., WARREN S.L., BILDERBACK T.E., 1998 - *Irrigation volume, application, and controlled-release fertilizers. Effect on plant growth and mineral nutrient content in containerized plant production*. - J. Environ. Hortic., 16(3): 176-181.

GRZEBISZ W., GGANSEE A., SZCZEPANIAK W., DIATTA J., 2013 - *The effects of potassium fertilization on water-use efficiency in crop plants.* - J. Plant Nut. Soil Sci., 176(3): 355-374.

IMRAN M., GURMANI Z.A., 2011 - *Role of macro and micro nutrients in the plant growth and development.* - Sci. Tech. Dev., 30: 36-40.

KANG J.G., FERRAREZI R.S., DOVE S.K., WEAVER G.M., VAN IERSEL M.W., 2016 - *Increased fertilizer levels do not prevent abscisic acid-induced chlorosis in Pansy*. - Hort. Tech., 26(5): 647-650.

KHOSA S.S., YOUNIS A., RAYIT A., YASMEEN S., RIAZ A., 2011 - *Effect of foliar application of macro and micro nutrients on growth and flowering of* Gerbera jamesonii *L.* - Agri. Envi. Sci., 11: 736-757.

LOH F.C.W., GRABOSKY J.C., BASSUK N.L., 2002 - *Using the SPAD502meter to assess chlorophyll and nitrogen content of Benjamin fig and cottonwood leaves.* - Hort. Technol., 12(4): 682-686.

LUCIDOS J.G., RYU K.B., YOUNIS A., KIM C., HWANG Y., SON B., LIM K., 2013 - *Different day and night temperature responses in* Lilium hansonii *in relation to growth and flower development.* - Hort. Envi. Biote., 54(5): 405-411.

MARIN M., VALDEZ-AGUILAR L.A., CASTILLO-GONZALEZ A.M., PINEDA J., GALVAN LUNA J.J., 2011 - *Modeling growth and ion concentration of* Lilium *in response to nitrogen, potassium, calcium mixture solution*. - J. Plant Nutr., 34(1): 12-26.

MAROYI A., 2016 - *Treatment of diarrhoea using traditional medicines: contemporary research in south africa and zimbabwe*. - Afr. Tradit. Complement. Altern. Med., 13(6): 5-10.

MARSCHNER H., 2012 - *Marschner's mineral nutrition of higher plants*. - Academic Press, Waltham, MA, USA, pp. 672.

McKENZIE K., 1989 - *Potted lilies made easy: The new, naturally short Asiatic lily varieties*. - GrowerTalks., 52: 48-58.

MENGEL K., KIRKBY E.A., 2001 - *Principles of plant nutrition, 5th edition* - Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 849.

NGUYEN P.M., KWEE E.M., NIEMEYER E.D., 2010 - *Potassium rate alters the antioxidant capacity and phenolic concentration of basil (*Ocimum basilicum *L.) leaves*. - Food. Chem., 123: 1235-1241.

OLFATI J.A., 2015 - *Design and preparation of nutrient solution used for soilless culture of horticultural crops*, pp. 33-45. - In: ASADUZZAMAN MD. (ed.) *Soilless Culture: Use of substrates for the production of quality.* Intech Open, London, UK.

PLANCHET E., VERDU I., DELAHAIE J., CUKIER C., GIRARD C., MORÈRE-LE PAVEN M.C., LIMAMI A.M., 2014 - *Abscisic acid-induced nitric oxide and proline accumulation in independent pathways under water-deficit stress during seedling establishment in* Medicago truncatula. - J. Exp. Bot., 65: 2161-2170.

PLAUT Z., ZIESLIN N., GRAWA A., GAZIT M., 1979 - *The response of rose plants to evaporative cooling: Flower production and quality*. - Sci. Hortic., 11(2): 183-190.

QUAGGIO J.A., SOUZA T.R., ZAMBROSI F.C., MATTROS D., BOARETTO R.M., SILVA G., 2019 - *Citrus fruit yield response to nitrogen and potassium fertilization depends on nutrient-water management system*. - Sci. Hortic., 249: 329-333.

RAVIV M., BLOM J., 2001 - *The effect of water availability and quality on photosynthesis and productivity of soilless-grown cut roses*. - Sci. Hortic., 88(4): 257-276.

ROUPHAEL Y., CARDARELLI M., REA E., COLLA G., 2008 - *The influence of irrigation system and nutrient solution concentration on potted geranium production under various conditions of radiation and temperature*. - Sci. Hortic., 118(4): 328-337.

ROUPHAEL Y., COLLA G., 2009 - *The influence of drip-irrigation or subirrigation on zucchini squash grown in closed-loop substrate culture with high and low nutrient solution concentrations*. - HortScience, 44: 306-311.

SAVVAS D., GIANQUINTO G., TUZEL Y., GRUDA N., 2013 - *Soilless Culture.* In: *Good agricultural practices for greenhouse vegetable crops. Principles for Mediterranean climate areas. FAO Plant production and protection paper 217*. - FAO, Rome, Italy.

TREDER J., 2003 - *Effects of supplementary lighting on flowering, plant quality and nutrient requirements of lily 'Laura Lee' during winter forcing*. - Sci. Hortic., 98:37-47.

TREDER J., 2005 - *Growth and quality of oriental Lilies at different fertilization levels*. - Acta. Horticulturae, 673: 297-302.

TSIROGIANNIS I., 2010 - *Effect of irrigation scheduling on gerbera flower yield and quality*. - HortScience, 45(2): 265-270.

VALDEZ-AGUILAR L.A., GRIEVE C.M., POSS J.A., MELLANO M.A., 2009 - *Hypersensitivity of* Ranunculus asiaticus *to salinity and alkaline pH in irrigation water in sand cultures.* - HortScience, 44: 138-144.

VATANSEVER R., OZYIGIT I.I., FILIZ E., 2017 - *Essential and beneficial trace elements in plants, and their transport in roots: A review.* - Appl. Biochem. Biotechnol., 181(1): 464-482.

WARAICH E.A., AHMAD R., ASHRAF M.Y., SAIFULLAH AHMAD M., 2011 - *Improving agricultural water use efficiency by nutrient management in crop plants*. - Acta Agr. Scand. B-S P., 61(4): 291-304.

WELSH D.F., ZAJICEL J.M., LYONS Jr. C.G., 1991 - *Effect of seasons and irrigation regimes on plant growth and water-use of container-grown* Photina fraseri. - Envi. Hort., 9: 79-82.

WOTMAN S.E., 2015 - *Crop physiological response to nutrient solution electrical conductivity and pH in an ebb-and-flow hydroponic system*. - Sci. Hort., 194:34-42.

YOUNIS A., ANJUM S., RIAZ A., HAMEED M., TARIQ U., AHSAN M., 2014 - *Production of quality Dahlia (*Dahlia variabilis *cv. Redskin) flowers by efficient nutrients management running title: Plant nutrition impacts on dahlia quality.* - Agri. Envi. Sci., 14(2): 137-142.