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Effect of amino acid (threonine), irrigation levels and their interaction on growth, flowering, bulbs productivity and chemical constituents of *Lilium longiflorum*, Thunb. plant

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ABSTRACT

The experiment trial was consummated throughout two successive seasons (2017 and 2018) at the nursery of Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. It intended to find out the effect of the individual as well as the combined effects of different irrigation levels (50, 75 and 100% of field capacity of growing medium used sand/clay, 1:1, v/v) and the effect of different levels of amino acid (threonine) at 50, 100 and 150 ppm) which was applied as a foliar spray on the plant on growth, flowering, bulb productivity and some chemical constituents of *Lilium longiflorum*, Thunb, with the aim to improve plant quality as well as saving the amount of water used in agriculture. Results emphasized the beneficial effect of applying either the moderate or the highest irrigation levels, with the mastery of the highest level in raising plant height and number of leaves/ plant in both seasons. Supplying plants with the highest irrigation level (100% of field capacity) proved its mastery in improving flowering parameters in both seasons expressed by flower stem diameter, flower diameter, fresh weight of cut flower, number of flowers /plant. However, receiving plants of the moderate irrigation level (75% of field capacity) occupied the second rank in improving the same traits in the two seasons. Meanwhile, root length and fresh weight of bulb were progressively increased by increasing irrigation level, recording the highest means by using the highest level. In contrast, inferior effects were observed on plant parameters due to receiving plants the lowest irrigation level (50% of field capacity). Moreover, it delayed flowering date than that gained from either the moderate or the highest irrigation levels used in the both seasons. Meanwhile, all studied plant traits progressively increased by increasing threonine level and reached the maximum values by using the highest level (150 ppm). On the other side, with regard to the effect of the different irrigation and threonine levels on chemical constituents of some plant parts (pigments contents N, P, K and total carbohydrates%), the scored values showed the prevalence of treating plants with the highest irrigation level, followed by the effect of the moderate one (100 and 75% of field capacity) as well as the beneficial effect of the highest threonine level (150 ppm) on improving chemical constituents of some plant parts.

From the aforementioned results it could be recommended to use either the moderate or the highest irrigation levels (75 and 100% of field capacity), with treating plants with the highest threonine level (150 ppm) for improving *Lilium longiflorum*, Thunb quality as well as saving the amount of water used in agriculture.

Keywords: Irrigation and fertilization levels, *Lilium longiflorum*, Thunb

Introduction

Lilium longiflorum, Thunb, family: Liliaceae, Japanese Easter lily. longtubed white lily. trumpet lily. Bulb 2-4 in. diameter, sometimes nearly globular, but more often of peculiar obvate form, all the scale terminating together at the top of pex, which is flattened, while the base is narrower or constricted, color white or yellow; stem stout, smooth, 1-3 ft. high, bright green, sometimes tinged reddish brown near the base; leaves 20 – 40, horizontal, or the upper ones semi-erect, 3-5 in. long, $^{1}/_{3}$-$^{1}/_{2}$ in. wide; flowers 1-10, 4-6 cm. in long, nearly as wide, pure waxy white, often tingted green near the base; deliciously fragrant, anthers yellow, (Bailey, 1933).

Lilium flowers are very popular in the local use and they are also demanded for exportation. It is ideal for pots, excellent cut flowers and can provide colour towards back of graden beds, Lilies are available for purchase in winter and early spring and are generally packed in a moist organic mix to

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keep the bulbs moist. Planting is immediately after delivery and do not allow the bulbs to dry out. This is very important bulbs are non tunicated

Quantifying the water requirements of every crop is very necessary to reduce the amount of used water in the agriculture production in Egypt. However, little informations are available in this concern especially in the field of ornamental plants. With the forth coming of the Ethiopian threat on Egypt quota of the water of the River Nile, are obliged to rationize our methods of irrigation and decrease the waste of water as much as possible.

A lot of authors discussed the problem of diminishing water resources and its impact on our life. Mohan and Vijayalakshmi (2009) stated that the quantity of water available for irrigation is getting scarce in many countries and it assumes great importance for assured crop production. Lucia (2009) remarked that knowledge of plant performance under reduced irrigation has the potential to reduce drastically the amounts of the applied container irrigation water. Iersel *et al* (2010) reported that more efficient irrigation practices are needed for ornamental plants production to reduce the amount of water used for production as well as runoff of fertilizer. Jensen *et al* (2010) stated that agriculture is a big consumer of fresh water in competition with other sectors of the society. Amoroso *et al* (2011) remarked that water stress is one of the primary constraints to plant productivity worldwide. Water availability for irrigation in agriculture and nursery industry will be reduced in the forth coming years. Alvares *et al* (2013) declared that irrigation water requirements and sensitivity to water deficits of ornamental plants is of great interest to horticultural producers for planning irrigation strategies.

Evapotranspiration of a crop is the sum of transpiration by the crop and evaporation from the soil surface during plant life, (Doorenbos and Pruitt, 1984). Various workers on different plants as, Eakes *et al* (1991 a and b) on *Salvia splendens*, Serp and Mattews (1994) on Begonia, El-Ashry *et al* (1998) on *Strelitizia reginae*. Ali *et al* (1998) on roses and Moftah and Al-Humid (2004) on *Polianthes tuberose* cv. Double, concluded that water availability was associated with the increase of vegetative growth and flowering of the plants, whereas soil stress caused steady decrease in plant performance. A decline in water potential would decrease the internal plant processes, such as net photosynthesis, cell division and enlargement and reduce epidermal cell turgor as noticed by Eakes *et al* (1991 a and b) on *Salvia splendens* Kiehl *et al* (1992) on chrysanthemum, Bastide *et al* (1993), Serp and Matthews (1994) on Begonia and Moftah and Al-Humid (2004) on tuberose.

Few information are available on the effect of irrigation levels on Lilium plant. So, the literature on other bulbs is indispensable in this respect. Bazaraa *et al* (2012) on Gladiolus cv. Novalux experimented the effect of different irrigation intervals (1, 2 and 3 weeks) on growth parameters of the plant. They concluded that plant height was progressively decreased by prolonging irrigation interval. They added that all flower parameters were also progressively decreased by prolonging irrigation interval such as flower stem length, rachis length, No. of flowers/flower and fresh weight of cut flower. Whereas, corms and cormlets parameters were gradually increased by prolonging irrigation intervals. Meanwhile, total carbohydrates content in the new corms was progressively decreased by prolonging irrigation interval, while N, P and K contents were gradualty increased by prolonging irrigation intervals. Khedr (2015) on *Hymenocallis speciosa*, Salisb concluded that great influence was noticed on plant parameters due to supplying plants with either moderate or high levels in every irrigation. Meanwhile, the lowest irrigation regime gave an intermediate effect on the same trait Elghazali (2016) recommended to use the low irrigation level (2 l/plant) with applying kristalon at the low concentration (2 g/l) for achieving high plant quality of *Gladiolus grandiflorus* cv. Peter Pears, besides saving the amount of water used in agriculture.

Amino acids have traditionally been considered as precursors and constituents of proteins, many amino acids also act as precursors of other nitrogen containing compounds, e.g. nucleic acids. Not long ago, many experiments implied that amino acids can play wide roles in plants including acting as regulatory and signaling molecules (Rai, 2002). Many scientists studied the effect of amino acids (as biostimulators) on growth, chemical composition, yield and its quality on plants. In this respect, Shehata *et al* (2011) concluded that spraying celeriac plants with amino acids at 500 and 750 ppm revealed that the higher rate (750 ppm) significantly increased plant height and fresh and dry weight of green yield (leaves). Moreover, the same rate (750 ppm) significantly increased total sugars content. Furthermore, amino acids are well known biostimulants which have positive effects on plant growth and yield and significantly mitigate the damage caused by abiotic stresses. In this connection, Sadak *et al* (2015), studied the effect of exogenously treatment of amino acids on faba bean Giza 843 plant growing under seawater stress, with the aim to reduce the reduction of salinity damage by using a mixture of amino acids with different concentrations (0, 500, 1000 or 1500 mg/l) to improve morphological parameters and thus raising the level of plant yield. Results indicated that the reductions in shoot length, number of leaves/plant, fresh and dry weight shoot, total carbohydrates caused by the irrigation of saline water (3.13 and 6.25 dsm^4), were alleviated by amino acid application as foliar spray significantly which improved all the reduced parameters due to seawater stress. In confirmation, the highest level of amino acids of 1500 mg/l exerted the strongest effect in alleviating the harmful effect of seawater salinity stress. Recently, Emam *et al* (2017) on *Moringa oliefera* stated that applying amino acid of threonine at 25 ppm caused an increment on number of leaves/plant.

Therefore, the present experiment was performed to find out the individual and the combined effects of different irrigation levels and threonine treatments on growth, flowering, bulbs productivity and some chemical constituents of *Lilium longiflorum*, Thunb with the aim to improve plant quality as well as saving the amount of water used in agriculture.

Materials and Methods

The present experiment was performed throughout two successive seasons (2017 and 2018) at the nursery of Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. The second season was an exact repition of the first one. It intended to find out the individual as well as the combined effects of different irrigation levels (50, 75 and 100% of field capacity or more properly pot capacity of growing medium used), (sand/ clay 1:1, v/v) and foliar application of different threonine levels (50, 100 and 150 ppm) on growth, flowering, bulbs productivity and some chemical constituents of *Lilium longiflorum*, Thunb plant.

Materials:

- Imported bulbs of *Lilium longiflorum*, Thunb of 18 – 20 cm. in circumference of average weight 70 – 100 g. were selected in the two seasons.
- Growing medium of the mixture of sand + clay (1:1, v/v) was used in both seasons. The physical and chemical properties of the growing medium are shown in Table (A).
- Amino acid of threonine at three levels (50, 100 and 150 ppm) were applied as a foliar spray.
- Plastic pots of 25 cm. diameter were used in both seasons.

Table (A): The physical and chemical properties of sand and clay used in plantation

Growth medium	Particle size distribution %				S.P	pH	EC dS/m^{-1}	Cations				Anions (meq/l)		
	Coarse sand	Fine sand	clay	silt				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO4^{--}$
Sand	88.04	3.21	0.72	8.03	21.07	7.75	3.46	13.46	4.98	20.4	0.62	2.40	14.50	22.56
Clay	1.20	22.6	21.3	54.5	42.30	7.40	1.51	2.94	1.29	3.89	2.30	3.54	4.33	2.55

Procedure:

Lilium longiflorum, Thunb bulbs were planted on Jonuary 2nd , in both seasons under open field condition in 25 cm. plastic filled with the mixture of sand+ clay (1:1, v/v) as one bulb for each pot. The bulbs were divided into three groups for studying the effect of irrigation levels (50, 75 and 100% of field capacity) of the growing media used. Beside, every group of irrigation levels was redivided again into four groups for studying the effect of the different levels of foliar application of threonine (control, 50 , 100 and 150 ppm). The plants received the different treatments of irrigation levels commencing from planting day. Whereas, foliar application of threonine was started on Februray 6th and then at 15 days intervals, where the plants received threonine treatments 8 times throughout the growing season. The quantaties of irrigation water which were applied for every pot of the different irrigation levels used were 257.95, 386.90 and 515.90 cm3/pot representing 50, 75 and 100% of field capacity of the growing medium used (sand/clay, 1:1, v/v). The plants were irrigated using the above mentioned allocation of water at three days interval during January and February, and at two days interval during March, April and May. 12 treatments were carried out in the two seasons (3 irrigation × 4 threonine treatments). A factorial experiment type in randomized complete block design (RCBD) with three replicates was employed in both seasons. The main plot was irrigation levels, whereas the second sub plot was threonine levels. Every treatment contained 12 bulbs and was replicated three times (4 bulbs for every experimental unite).

Regular agricultural practices were carried out whenever needed.

The following data were recorded in both seasons: plant height (cm.) and number of leaves/ plant at flowering stage, number of days from planting to flowering, flower stem diameter (cm.), flower diameter (cm.), fresh weight of cut flower (g.), No. of flowers/plant, root length (cm.) and fresh weight of bulb (g.).

In the second season, the following constituents were determined of Chlorophyll a , b and carotenoides (mg./g.f.w.) according to Wettstein (1957). Meanwhile, at the end of the same season, the following constituents in dry samples of the new formed bulbs were determined nitrogen (Blake, 1965), phosphorus (John, 1970), potassium (Dewis and Freitas, 1970) and total carbohydrates content (Dubois *et al*, 1956)

Data were then tabulated and statistically analyzed using SAS program (1994) and means were compared by L.S.D. method according to Snedecor and Cochran (1980).

Results and Discussion

Effect of irrigation and threonine levels on vegetative growth parameters:

Data exhibited in Table (1) exert the beneficial effect of applying the moderate and the highest irrigation levels (75 and 100% of field capacity) in raising plant height with significant effect in both seasons. However, the highest one was the best in the two seasons, (66.82, 70.32 cm. in the first season and 69.01, 72.51 cm. in the second one, respectively).

Table 1: Effect of irrigation and threonine levels on plant height (cm.) of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation	1st season				2nd season			
Threonine (ppm)	**50%**	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	59.86	62.86	66.86	**63.19**	62.07	65.07	69.06	**65.40**
50	64.03	67.22	71.22	**67.49**	66.24	69.43	73.43	**69.70**
100	64.73	67.44	71.44	**67.87**	66.94	69.65	73.65	**70.08**
150	65.58	69.75	71.75	**69.03**	67.72	71.89	73.89	**71.17**
Mean	**63.55**	**66.82**	**70.32**		**65.74**	**69.01**	**72.51**	
LSD at 0.05	**A= 3.366**	**B= 4.294**	**A×B= 6.733**		**A= 4.891**	**B= 5.031**	**A×B= 7.399**	

Threonine treatments on the other side, improved plant height than that gained from control, with the superiority of applying the highest level (150 ppm) in both seasons giving 69.03 and 71.17 cm. against 63.19 and 65.40 cm. of control means in first and second seasons, respectively.

In this connection, the promotive effect of amino acid in improving plant height was also recorded by Shehata *et al* (2011) on Celeric plants. They concluded that spraying the plant with amino acids at 500 and 750 ppm revealed that the higher rate (750 ppm) significantly increased plant height. Similarly, was the effect on the same parameter recorded by Datir *et al* (2012) on *Capsicum annum*.

In the matter of the interaction, it is evident from scored values, the mastery of receiving plant the highest irrigation level with applying the highest threonine level (150 ppm) in elevating plant height as it gave the utmost high values in the two seasons, registering 71.75 and 73.89 cm. in the first and second seasons, respectively. In contrast, the lowest means were obtained from plants which received the lowest irrigation level (50% of field capacity) and untreated with threonine, scoring only 59.86 and 62.07 cm. in the first and second seasons, respectively.

Concerning the effect of irrigation levels on number of leaves /plant it is obvious from data outlined in Table (2) the beneficial effect of using either the moderate or the highest irrigation level, with the superiority of the highest one (100% of field capacity) in elevating number of leaves/ plant, registering 24.24 and 26.83 in the first season and 25.53 and 28.12 in the second one, respectively.

The beneficial effect of treating plants with the different threonine levels in improving number of leaves/ plant was noticed in both seasons. However, it could be mentioned that applying the highest threonine level (150 ppm) was the best in raising such trait in the two seasons as it gave the utmost high values in both seasons, recording 29.19 and 30.48 against 20.31 and 21.50 of control means in the first and second seasons, respectively.

In this respect the beneficial effect of threonine in raising number of leaves/ plant was also confirmed by Emam *et al* (2017) on *Moringa oliefera* mentioning that applying amino acid of threonine at 25 ppm caused an increment on number of leaves/ plant.

With regard to the interaction, it is clear from data presented in Table (2) the prevalence of plants which received the highest irrigation level (100% of field capacity) and treated with the highest threonine level (150 ppm) for increasing number of leaves/ plant in both seasons, registering 33.42 and 34.71 in the first and second seasons, respectively. The opposite was the right for plants which received the lowest irrigation level (50% of field capacity) and untreated with theronine, giving only 16.98 and 18.27 in the first and second seasons, respectively.

Table 2: Effect of irrigation and threonine levels on number of leaves/ plant of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation	**1st season**				**2nd season**			
Threonine (ppm)	**50%**	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	16.98	20.98	22.98	**20.31**	18.27	22.27	24.27	**21.50**
50	18.86	22.86	24.86	**22.20**	20.15	24.15	26.15	**23.49**
100	20.05	24.05	26.05	**23.38**	21.34	25.34	24.34	**24.67**
150	25.08	29.08	33.42	**29.19**	26.37	30.37	34.71	**30.48**
Mean	**20.24**	**24.24**	**26.83**		**21.53**	**25.53**	**28.12**	
LSD at 0.05	**A= 1.267**	**B= 1.616**	**A×B= 2.098**		**A= 1.563**	**B= 1.832**	**A×B= 2.401**	

Results of the effect of different irrigation levels on vegetative growth parameters, expressed as plant height and number of leaves/ plant, revealed the prevalence of using the high and to some extent the moderate irrigation levels in increasing these parameters in the two seasons. However, such result was interpreted by the finding of many authors on some plant species. In this connection, the increase in plant height could be explained by either increasing the number of cell layers in cell expanding zone and the cambial zone or as a result of water availability that increased cell enlargement over cell division (Abe and Nakai, 1999). However, El-Shakhs *et al* (2002) on *Dahlia pinnata* stated that increasing quality of water improved plant height and leaf number/ plant. El-Hanafy *et al* (2006) on *Ornithogalum thyrsoides* investigated the effect of irrigation periods (at 1, 3, 5, 7 and 9 days interials) on the growth of the plant. The results showed that using the shortest irrigation period (at daily interval) proved its superiority in improving vegetative growth heigh and number of leaves/ plant. Bazaraa *et al* (2012), on Gladiolus cv. Novalux experimented the effect of different irrigation intervals (1, 2 and 3 weeks) on growth parameters of the plant. They concluded that plant height was progressively decreased by prolonging irrigation interval. Khedr (2015) on *Hymenocallis speciosa*, Salisb concluded that great influence was noticed on vegetative growth due to supplying plants with either moderate or high level in every irrigation. Meanwhile, the lowest irrigation regime gave an intermediate effects on the same trait.

Effect of irrigation and threonine levels on flowering traits:

Referring to the effect of the different irrigation levels on the time required from planting to flowering (days) it is evident from data scored in Table (3), that receiving plants the lowest irrigation level (50% of field capacity) tended to delay flowering, with significant effect than that gained from plants which received either the moderate or the highest irrigation levels in both seasons. Such treatment raised number of days from planting to flowering to 118.60 and 120.87 days in the first and second seasons, respectively.

In this respect, the delay in flowering date due to the level irrigation is in conformity with that observed by Nabih *et al* (1992 a) *on Freesia refracta* cv. Aurora. They found that prolonging irrigation period to 4 weeks slightly delayed flowering.

On the other hand, number of days from planting to flowering was progressively increased by increasing threonine levels in both seasons, giving the utmost high values by applying the highest level (150 ppm) scoring 117.61 and 119.75 days against 114.39 and 116.36 days of untreated control plants in the first and second seasons, respectively.

Table 3: Effect of irrigation and threonine levels on number of days from planting to flowering of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	116.95	113.95	112.28	**114.39**	119.16	115.42	114.49	**116.36**
50	118.58	115.56	113.56	**115.90**	120.79	117.77	115.77	**118.11**
100	119.03	116.10	114.10	**116.41**	121.23	118.31	116.30	**118.62**
150	120.17	117.33	115.33	**117.61**	122.31	119.47	117.47	**119.75**
Mean	**118.60**	**115.74**	**113.82**		**120.87**	**117.75**	**116.01**	
LSD at 0.05	**A= 0.543**	**B= 0.692**	**A×B= 1.209**		**A= 0.354**	**B= 0.408**	**A×B= 1.085**	

With respect to the interaction, it is obvious from data presented in Table (3) that the earlist flowering was a result of plants which received the highest level of irrigation (100% of field capacity) and untreated with threonine in both seasons, scoring only 112.28 and 114.49 days in the first and second seasons, respectively. On the contrary, the highest values were obtained due to plants which received the lowest irrigation level (50% of the field capacity) and treated with the highest threonine level (150 ppm) scoring 120.17 and 122.31 days in the first and second seasons, respectively.

Flower stem diameter progressively increased as a result of increasing irrigation levels, giving the utmost high values with receiving plants the highest level (100% of field capacity), registering 0.61and 0.72 cm. in the first and second seasons, respectively. Meanwhile, the lowest means were recorded due to applying the lowest irrigation level (50% of field capacity) as 0.46 and 0.58 cm. in the first and second seasons, respectively, with significant effects in both seasons. In this regard, the beneficial effect of high irrigation level on increasing stem diameter was in accordance with Khedr (2015) on *Hymenocallis speciosa*, Salisb.

On the other side, using the different threonine levels caused an increment in flower stem diameter in the two seasons, with the superiority of applying the highest level (150 ppm), recording 0.61 and 0.72 cm. against 0.50 and 0.61 cm. of untreated control plants in the first and second seasons, respectively.

In the matter interaction, it is clear from data listed in Table (4) the prevalence of receiving plants the highest irrigation level (100% of field capacity) with applying the highest threonine level (150 ppm), in elevating flower stem diameter registering 0.71 and 0.82 cm. in the first and second seasons, respectively. In contrast, the lowest means were recorded due to plants which received the lowest irrigation level (50% of field capacity), untreated with threonine in the two seasons giving 0.42 and 0.53 cm., respectively.

Table 4: Effect of irrigation and threonine levels on flower stem diameter (cm.) of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	0.42	0.53	0.54	**0.50**	0.53	0.64	0.65	**0.61**
50	0.46	0.56	0.59	**0.54**	0.57	0.67	0.70	**0.65**
100	0.48	0.58	0.60	**0.55**	0.59	0.69	0.71	**0.66**
150	0.50	0.61	0.71	**0.61**	0.61	0.72	0.82	**0.72**
Mean	**0.46**	**0.57**	**0.61**		**0.58**	**0.68**	**0.72**	
LSD at 0.05	**A= 0.0323**	**B= 0.0412**	**A×B= 0.855**		**A= 0.0522**	**B= 0.0609**	**A×B= 0.943**	

Clear differences were detected on flower diameter in both seasons, resulting from applying the different irrigation levels, as the significantly highest values were gained due to using the highest irrigation level (100% of field capacity), 10.51 and 11.50 cm. against of 8.36 and 9.45 of that obtained from plants treated with the lowest irrigation level (50% of field capacity) in the first and second seasons, respectively. Meanwhile, receiving plants the moderate irrigation level (75% of field capacity) occupied the second rank in raising flower diameter (9.56 and 10.65 cm. in the first and second seasons, respectively).

Table 5: Effect of irrigation and threonine levels on flower diameter (cm.) of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season 50%	75%	100%	Mean	2nd season 50%	75%	100%	Mean
Control	8.00	9.27	10.20	9.16	9.10	10.36	11.29	10.25
50	8.25	9.45	10.16	9.28	9.34	10.54	11.25	10.37
100	8.47	9.68	10.58	9.58	9.56	10.77	11.67	10.67
150	8.71	9.85	10.68	9.75	9.80	10.94	11.77	10.84
Mean	**8.36**	**9.56**	**10.41**		**9.45**	**10.65**	**11.50**	
LSD at 0.05	**A= 0.198**	**B= 0.253**	**A×B= 0.478**		**A= 0.285**	**B= 0.344**	**A×B= 0.625**	

In this connection, the prevalence of high irrigation level in improving flower diameter was also recorded by El-Shakhs *et al* (2002) on *Dahlia pinnata* and Khedr (2015) on *Hymenocallis speciosa*, Salisb.

Slight effects, on the other side, were observed on the same trait due to applying the different threonine levels in both seasons. However, applying the highest level (150 ppm) was the best in this concern.

With respect to the interaction, it is evident from scored values that plants which received the highest irrigation level (100% field capacity) and treated with the highest threonine level (150 ppm) proved mastery in elevating flower diameter in the two seasons (16.68 and 11.77 cm., respectively). However, plants which received the lowest irrigation level (50% of field capacity) and untreated with threonine recorded the lowest means in the two seasons (8.00 and 0.10 cm., respectively).

In both seasons, the significantly heaviest fresh weight of cut flower was obtained due to receiving plants the highest irrigation level (100% of field capacity), registering 42.57 and 43.96 gm. against 38.06 and 39.45 gm., resulting from using the lowest level (50% of field capacity) in the first and second seasons, respectively. Meanwhile, receiving plants the moderate level (75% of field capacity) occupied the second rank in raising fresh weight of cut flower, scoring 39.66 and 41.05 g. in the first and second seasons , respectively.

The utmost high values of fresh weight of cut flower resulted from suppling plants with the highest threonine level (150 ppm), recording 42.35 and 43.74 g. against 37.52 and 38.91 g. of control means in the first and second seasons, respectively.

Table 6: Effect of irrigation and threonine levels on fresh weight of cut flower (g.) of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season 50%	75%	100%	Mean	2nd season 50%	75%	100%	Mean
Control	35.86	37.86	38.83	**37.52**	37.25	39.25	40.22	**38.91**
50	37.41	39.07	41.41	**39.30**	38.80	40.46	42.80	**40.69**
100	39.12	40.45	44.12	**41.23**	40.51	41.84	45.51	**42.62**
150	39.85	41.26	45.93	**42.35**	41.24	42.65	47.32	**43.74**
Mean	**38.06**	**39.66**	**42.57**		**39.45**	**41.05**	**43.96**	
LSD at 0.05	**A= 0.751**	**B= 0.958**	**A×B= 1.659**		**A= 0.925**	**B= 1.080**	**A×B= 2.113**	

Results of the interaction, cleared that plants which received the highest irrigation level (1005 of field capacity) and treated with the highest threonine level (150 ppm) was the best treatment used in elevating fresh weight of cut flower in the two seasons. Meanwhile, the opposite was the right for plants which received the lowest irrigation level (50% of field capacity) and untreated with threonine, giving only 35.86 and 37.23 g. in the first and second seasons, respectively.

As shown from data outlined in Table (7), the highest number of flowers/ plant was gained as a result of receiving plants the highest irrigation level (100% of field capacity) recording 3.93 and 4.72 against of 3.16 and 3.96 of plants treated with lowest irrigation level (50% of field capacity) in the first and second seasons, respectively. Meanwhile, using the moderate irrigation level (75% of field capacity) occupied the second rank in increasing number of flowers/ plant, registering 3.53 and 4.33 in the first and second seasons, respectively.

In this connection, the beneficial effect of high irrigation level in raising number of flowers/ plant was also recorded by Khedr (2015) on *Hymenocallis speciosa*, Salisb.

Generally, it could be cocluded that number of flowers/plant was progressively increased by increasing threonine level giving the utmost high values with plants which received the highest level (150 ppm) giving 3.92 and 4,71 against 3.16 and 3.95 resulted from untreated control plants in the first and second seasons, respectively.

Concerning the interaction, the obtained values cleared the favourable effect of supplying plants with the highest irrigation level (100% of field capacity) and treating plants with the highest threonine level (150 ppm) in elevating number of flowers/ plant in the two season, scoring 4.48 and 5.28 in the first and second season, respectively. In contrast the least scores were a result of plants which received the lowest level (50% of field capacity), untreated with threonine in both seasons (2.92 and 3.71 in the first and second seasons, respectively).

Table 7: Effect of irrigation and threonine levels on number of flowers/ plant of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation	1st season				2nd season			
Threonine (ppm)	**50%**	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	2.92	3.22	3.34	**3.16**	3.71	4.03	4.16	**3.95**
50	3.15	3.47	3.87	**3.49**	3.94	4.26	4.66	**4.29**
100	3.18	3.55	4.03	**3.59**	3.97	4.34	4.80	**4.38**
150	3.40	3.87	4.48	**3.92**	4.20	4.66	5.28	**4.71**
Mean	**3.16**	**3.53**	**3.93**		**3.96**	**4.33**	**4.72**	
LSD at 0.05	**A= 0.260**	**B= 0.332**	**A×B= 0.805**		**A= 0.419**	**B= 0.507**	**A×B= 0.975**	

The aforementioned results showed the superiority of using the highest irrigation level (100% of field capacity) for improving plant parameters, whereas the lowest level of 50% declined to some extrent plant parameters. In this connection many authors as Eakes *et al* (1991 a and b) on *Salvia splendens*, Kiehl et al (1992) on Chrysanthemum, Bastide *et al* (1993), Serp and Matthews (1994) on Begonia and Moftah and Al-Humid (2004) on tuberose concluded that a decline in water potential would decrease the internal plant processes, such as net photosynthesis, cell division and enlargement and reduce the epidermal cell turgor.

However the above mentioned results are in confirmity with the findings of a lot of scientists on various plant species. Nabih (1992 a) on *Freesia refracta* cv. Aurora concluded that prolonging irrigation period to four weeks slightly delayed flowering, decreased number of flowers/ plant and total flowers/ plant. Also, Nabih *et al* (1992 b) on *Polianthes tuberosa* concluded that irrigation treatments of 7and 12 days intervals increased flowers yield and improved flower quality. They had mostly similar effects on the different morphological traits studied. Meanwhile, prolonging irrigation period to 17 and 22 days showed a decline effect on flowers quality and yield. El-Shakhs *et al* (2002) on *Dahlia pinnata* stated that increasing quantity of water improved flower diameter, flower stem length and dry weight of cut flowers. Saleh (2005) on *Strelitizia reginae* plants raised in 20 cm. clay pots filled with the mixture of peatmoss + sand (1:1, v/v) concluded that applying irrigation of three days intervals gained better results than from other 6 and 9 days interval for all plant parameters. El-Hanafy *et al* (2006) on *Ornithogalum thyrsoides* grown in 20 cm. clay pots mentioned that using the shortest irrigation interval (daily interval) proved superior than other treatments in improving most plant parameters such as inflorescence stem diameter and length, number of flowers/ plant and fresh weight of cut inflorescence. Bazaraa *et al* (2012) on Gladiolus cv. Novalux studied the effect of different irrigation intervals (1, 2 and 3 weeks) on flowering parameters of the plant. They found that all flowering parameters, were progressively decreased by prolonging irrigation intervals, such as flower stem length, rachis length, No. of flowers/ plant and fresh weight of cut flower.

Effect of irrigation and threonine levels on under ground parts:

Clear differences were observed on root length (cm.) as a result of applying the different irrigation levels in both seasons. In this connection, receiving plants the highest irrigation level (100% of field capacity) proved its mastery in elevating root length in both seasons, registering 23.40 and 24.90 cm. against 18.67 and 20.17 resulted from using the lowest irrigation level (50% of field capacity) in the first and second seasons, respectively. Meanwhile, treating plants with the moderate irrigation level (75% of field capacity) occupied the second rank for improving root length registering 20.31 and 22.21 cm. in the first and second seasons, respectively.

The favourable effect of the high irrigation level in improving root length was ascertained by the findings of Mortimer et al (2003), on *Protea hybrida* (Syliva) where the plants which were exposed in the glasshouse to watering regimes maintaining water at 20, 40 and 60% of field capacity in sand filled pots. They revealed that higher water supply in increased growth of the roots, reaching a maximum at 40% of field capacity. Garas (2011), on *Hibiscus rosa-siensis* cv. Apple Blossom concluded that a beneficial effect on root length was observed due to supplying plants with the moderate (0.75 l/pot) irrigation level in the two seasons. Moreover, Khedr (2015) on *Hymenocallis speciosa*, Salisb. concluded that the highest results were gained in root length (cm.) due to applying the moderate and the high irrigation levels of 100% and 75% of field capacity.

The different threonine levels, on the other side, caused an increment on root length in both seasons, with the mastery of applying the highest level (150 ppm), scoring 22.85 and 24.35 against 18.31 and 19.83 resulted from untreated plants (control) in first and second seasons, respectively.

In the matter of interaction, it is evident that receiving plants the highest irrigation level (100% of field capacity) with treating them with the highest threonine level (150 ppm) was the best treatment used for raising root length, scoring 25.58 and 27.08 cm. in the first and second seasons, respectively. The opposite was the right for plants which received the lowest irrigation level (50% of field capacity) untreated with threonine in both seasons, registering only 16.42 and 17.92 cm. in the first and second seasons, respectively.

Table 8: Effect of irrigation and threonine levels on root length (cm.) of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation	**1st season**				**2nd season**			
Threonine (ppm)	**50%**	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	16.42	18.26	20.26	**18.31**	17.92	19.75	21.75	**19.83**
50	18.21	20.50	23.17	**20.63**	19.71	22.00	24.66	**22.12**
100	19.57	21.59	24.59	**21.92**	21.06	23.10	26.11	**23.41**
150	20.48	22.46	25.58	**22.85**	21.98	23.97	27.08	**24.35**
Mean	**18.67**	**20.71**	**23.40**		**20.17**	**22.21**	**24.90**	
LSD at 0.05	**A= 1.667**	**B= 2.127**	**A×B= 3.684**		**A= 1.917**	**B= 3.522**	**A×B= 4.208**	

Fresh weight of bulb was progressively increased with increasing irrigation level, to reach its maximum by receiving plants the highest level (100% of filed capacity), followed in the second rank by applying the moderate irrigation level (75% of field capacity) scoring 45.74 and 42.74 gm. in the first season and 47.33 and 44.33 gm. in the second one, respectively.

The clear increment of fresh weight of the newly formed bulbs due to using the moderate and the highest irrigation level (75 and 100% of field capacity) is in confirmity with the findings of many scientists on other plants. Neeraja *et al* (1999) studied the effect of four levels of irrigation on rabi onion (*Allum cepa*, L.) grown in sandy loamy soil. They found that the higher level of irrigation resulted in maximum bulb length, bulb diameter and bulb weight. Lal *et al* (2002) studied the effects of irrigation levels on bulbs production. They found that bulb size and bulb yield increased with increasing rates of irrigation. El-Shakhs *et al* (2002) on *Dahlia pinnata* reported that increasing quantities of water improved tuberous roots yield. El-Hanafy *et al* (2006) on *Ornithogalum thyrsoides* grown in 20 cm. clay pots mentioned that using the shortest irrigation interval (daily interval) proved superior than other treatments for improving fresh weight of bulb.

All threonine levels caused a clear increment on fresh weight of bulb in the two seasons, with the superiority of applying the highest level which gave the utmost high values, scoring 45.22 and 46.81 gm. in the first and second seasons, respectively.

The interaction revealed that plants which received the highest irrigation level (100% of field capacity) and treated with highest threonine level (150 ppm) gave the utmost high values in both seasons (49.23 and 50.93 gm., respectively). In contrast, the least scores were obtained due to receiving plants the lowest irrigation level (50% of field capacity) and untreated with threonine, registering only 32.25 and 33.84 gm. in the first and second seasons, respectively.

Table 9: Effect of irrigation and threonine levels on fresh weight of bulb (gm.) of *Lilium longiflorum*, Thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	32.25	37.91	40.90	37.02	33.84	39.50	42.49	38.61
50	35.79	42.69	45.69	41.39	37.38	44.38	47.28	42.98
100	37.69	44.02	47.03	42.92	39.28	45.61	48.62	44.51
150	40.00	46.32	49.33	45.22	41.59	47.92	50.93	46.81
Mean	**36.43**	**42.74**	**45.74**		**38.02**	**44.33**	**47.33**	
LSD at 0.05	**A= 2.163**	**B= 2.759**	**A×B= 4.326**		**A= 3.250**	**B= 4.098**	**A×B= 6.521**	

Chemical constituents of the plant:

Pigments content in leaves:

It is evident from data registered in Tables (10-12) that the highest records of chlorophyll (a), chlorophyll (b) and carotenoides were a result of receiving plants the highest irrigation level (100% of field capacity), which occupied the first rank, followed in the second rank by plants which treated with the moderate rate (75% of field capacity), then came the effect of the lowest irrigation level (50% of field capacity), which scored the lowest means in this regard.

The previous results on the effect of different irrigation levels on pigment content show the favourable effect on such trait in leaves due to using the moderate or the highest irrigation level. This result was interpreted by the finding of many authors. El-Khateeb (1996), on fig transplants grown under different soil moisture levels stated that a decrement in leaf pigment content (chlorophyll b and carotenoides) was noticed as a recult of growing plants under stress condition. Khedr (2015) on *Hymenocallis speciosa*, Salisb concluded that the moderate and the highest irrigation levels were the best for elevating either chlorophyll a or b content in most cases.

Referring to the effect of threonine treatments it is obvious from data that the highest level (150 ppm) was the best treatment used in raising pigments content in the leaves in the two seasons, and the opposite was the right by using the lowest level (50 ppm) which gave the least scores in both seasons.

Table 10: Effect of irrigation and threonine levels on chlorophyll a (mg/g.f.w.) of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	0.54	0.61	0.64	**0.60**	0.60	0.67	0.70	**0.67**
50	0.55	0.64	0.68	**0.62**	0.61	0.70	0.74	**0.69**
100	0.57	0.69	0.72	**0.66**	0.63	0.75	0.78	**0.73**
150	0.61	0.70	0.80	**0.70**	0.67	0.76	0.86	**0.76**
Mean	**0.57**	**0.66**	**0.71**		**0.63**	**0.72**	**0.77**	
LSD at 0.05	**A= 0.064**	**B= 0.083**	**A×B= 0.175**		**A= 0.072**	**B= 0.088**	**A×B= 0.193**	

Table 11: Effect of irrigation and threonine levels on chlorophyll b (mg/g.f.w.) of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	**75%**	**100%**	**Mean**	**50%**	**75%**	**100%**	**Mean**
Control	0.17	0.20	0.22	**0.20**	0.25	0.28	0.30	**0.28**
50	0.18	0.21	0.23	**0.21**	0.26	0.29	0.31	**0.29**
100	0.20	0.24	0.25	**0.23**	0.28	0.32	0.33	**0.31**
150	0.21	0.25	0.28	**0.24**	0.29	0.33	0.36	**0.32**
Mean	**0.19**	**0.23**	**0.25**		**0.27**	**0.31**	**0.33**	
LSD at 0.05	**A= 0.011**	**B= 0.025**	**A×B= 0.098**		**A= 0.023**	**B= 0.031**	**A×B= 0.102**	

Table 12: Effect of irrigation and threonine levels on carotienods (mg/g.f.w.) of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	0.42	0.44	0.51	**0.46**	0.51	0.53	0.60	**0.55**
50	0.44	0.45	0.53	**0.48**	0.53	0.54	0.62	**0.57**
100	0.46	0.47	0.55	**0.49**	0.55	0.56	0.64	**0.58**
150	0.48	0.49	0.60	**0.52**	0.57	0.58	0.69	**0.61**
Mean	**0.45**	**0.46**	**0.54**		**0.54**	**0.55**	**0.53**	
LSD at 0.05	**A= 0.0382**	**B= 0.0422**	**A×B= 0.090**		**A= 0.0425**	**B= 0.0502**	**A×B= 0.115**	

The interaction, on the other side, indicated the superiority of receiving plants the highest irrigation level (100% of field capacity) and treated with the highest threonine level (150 ppm) in elevating the scored values in both seasons. In contrast, the least scores were gained as a result of plants which received the lowest irrigation level (50% of field capacity) and untreated with threonine in the two seasons.

Total carbohydrates % in bulb:

Obviously data registered in Table (13) proved the mastery with significant effect of using the highest irrigation level (100% of field capacity) in increasing total carbohydrates % in the new bulbs in both seasons, followed by plants which received the moderate irrigation level (75% of field capacity), which occupied the second rank in this respect. However, the least scores were obtained due to applying the lowest irrigation level (50% of field capacity).

Table 13: Effect of irrigation and threonine levels on total carbohydrates (%) of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	31.25	34.66	36.92	**34.28**	40.36	43.75	45.85	**43.33**
50	33.85	36.57	38.08	**36.17**	42.93	45.68	47.19	**45.28**
100	38.40	38.83	41.33	**39.52**	47.51	47.90	50.42	**48.61**
150	41.08	44.00	45.42	**43.50**	50.19	53.12	54.53	**52.63**
Mean	**36.15**	**38.52**	**40.44**		**45.26**	**47.63**	**49.56**	
LSD at 0.05	**A= 1.556**	**B= 2.422**	**A×B= 3.098**		**A= 1.872**	**B= 2.751**	**A×B= 4.124**	

The favourable effect of the high or moderate irrigation levels on total carbohydrates % in the bulbs is in agreement with Khedr (2015) on *Hymenocallis speciosa* plant, recording the beneficial effect of the two irrigation levels of either the high or the moderate levels for increasing total carbohydrates % in new bulbs.

On the other side, the positive significant influence on total carbohydrates % in the new bulbs was gained due to applying threonine at the highest level (150 ppm), followed in the second degree with significant difference by plants which treated with the moderate threonine level (100 ppm). However, Shehata *et al* (2011) concluded that spraying celeriac plants with amino acid at 750 ppm significantly increased total sugars content.

In the matter of the interaction, it is evident from tabulated data the promotive effect of receiving plants the highest irrigation level (100% of field capacity) with treating plants with the highest threonine level (150 ppm) in raising total carbohydrates % in the two seasons as indicated in Table (13). In contrast, the least means were gained due to plants which received the lowest irrigation level (50% of field capacity) and untreated with threonine in the two seasons.

Minerals % in bulb (N, P and K):

It is clear from data outlined in Tables (14-16) the prevalence of receiving plants the highest irrigation level (100% of field capacity) in increasing minerals (N, P and K%) in the new bulbs comparing with that gained from the other levels used in the two seasons. In contrast, the least values were recorded as a result of applying the lowest irrigation level (50% of field capacity).

Referring to the effect of threonine treatments on the above mentioned traits, the obtained values indicated that all minerals (N, P and K%) were progressively increased by increasing threonine levels as indicated in Tables (14-16).

With respect to the interaction, it is clear from the obtained values the great influence of supplying plants with the highest irrigation level (100% of field capacity) with treating plants with the highest threonine levels (150 ppm) in improving minerals (N, P and K%) in the new bulbs in the two seasons.

Table 14: Effect of irrigation and threonine levels on nitrogen % of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	1.07	1.14	1.52	**1.24**	1.61	1.73	2.11	**1.83**
50	1.15	1.24	1.60	**1.33**	1.74	1.83	2.19	**1.92**
100	1.20	1.30	1.64	**1.38**	1.79	1.89	2.23	**1.97**
150	1.27	1.35	1.72	**1.44**	1.86	1.94	2.31	**2.03**
Mean	**1.17**	**1.25**	**1.61**		**1.76**	**1.84**	**2.20**	
LSD at 0.05	**A= 0.152**	**B= 0.177**	**A×B= 0.304**		**A= 0.173**	**B= 0.182**	**A×B= 0.355**	

Table 15: Effect of irrigation and threonine levels on phosphors % of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	0.28	0.42	0.72	**0.47**	0.37	0.51	0.81	**0.56**
50	0.32	0.51	0.81	**0.54**	0.41	0.60	0.90	**0.63**
100	0.37	0.64	0.92	**0.64**	0.46	0.73	1.01	**0.73**
150	0.44	0.73	1.10	**0.76**	0.53	0.82	1.19	**0.85**
Mean	**0.35**	**0.58**	**0.89**		**0.44**	**0.67**	**0.98**	
LSD at 0.05	**A= 0.128**	**B= 0.150**	**A×B= 0.311**		**A= 0.132**	**B= 0.185**	**A×B= 0.416**	

Table 16: Effect of irrigation and threonine levels on potassium % of *Lilium longiflorum*, thunb during 2017 and 2018 seasons.

Irrigation / Threonine (ppm)	1st season				2nd season			
	50%	75%	100%	Mean	50%	75%	100%	Mean
Control	1.02	1.05	1.12	1.06	1.10	1.13	1.20	1.14
50	1.04	1.07	1.20	1.10	1.12	1.15	1.28	1.18
100	1.06	1.11	1.24	1.14	1.14	1.19	1.32	1.22
150	1.09	1.15	1.33	1.19	1.17	1.23	1.41	1.27
Mean	**1.05**	**1.10**	**1.22**		**1.13**	**1.18**	**1.30**	
LSD at 0.05	**A= 0.095**	**B= 0.101**	**A×B= 0.182**		**A= 0.100**	**B= 0.118**	**A×B= 0.202**	

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