

## EFFECTS OF DIFFERENT IRRIGATION TREATMENTS ON QUALITY PARAMETERS OF CUT CHRYSANTHEMUM

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### Abstract

*This study was carried out to determine the effects of different irrigation intervals and water amounts on yield and quality parameters of cut chrysanthemum. Spray cut chrysanthemum (cv. 'Bacardi') plant was used as a plant material. Class A pan was placed in the greenhouse to determine the amount of irrigation water values. Irrigation treatments consisted of three irrigation intervals ( $I_1$ : 2-,  $I_2$ : 4-, and  $I_3$ : 6-day) and four crop-pan coefficients ( $k_{cp1}$ : 1.20= $T_1$ ,  $k_{cp2}$ : 0.90= $T_2$ ,  $k_{cp3}$ : 0.60= $T_3$ , and  $k_{cp4}$ : 0.30= $T_4$ ). The irrigation water amounts applied to the experimental treatments ranged from 249.7 to 517.9 mm, and seasonal evapotranspiration ranged from 340.9 to 560.5 mm. Different irrigation water amounts and irrigation intervals had statistically significant effects on flower stem length, stem diameter, stem weight, the number of flowers, the vase life and root length of chrysanthemum. Stem length varied between 52.36-79.81 cm, stem diameter varied between 4.62-7.69 mm, stem weight varied between 32.48-123.61 g and root length varied between 18.88-24.22 cm. The optimum irrigation scheduling was  $T_1I_1$ , in which the longest flower stem and the highest stem weight were obtained.*

**Key words:** *Chrysanthemum, Class A Pan, Evapotranspiration, Irrigation interval, Water deficit.*

### INTRODUCTION

The total production area of ornamental plants worldwide is 1.573.167 ha according to the data of 2013. Some 651.800 ha of it is composed of cut flowers and pot plants. The important production regions according to land areas are Asia, North America, Europe, South America, Africa, and the Middle East. The continent with the largest production area for cut flowers and pot plants worldwide is Asia-Pacific (468.000 ha) (Anonymous, 2013). Chrysanthemum is one of the major cut flowers in the world. The demand for the flower reached 35% of the overall market request, second only to roses (Steen, 2010).

As in all plants, irrigation is an essential practice for chrysanthemum growing, but its adequate handling has been neglected by growers, resulting in growing loss and consequent productivity and quality decreases in the final product (Farias et al., 2009). In order to irrigate more extensive areas with the available water resources, such factors as soil,

plant, and water resource must be taken into consideration. In addition, the values of plant water consumption under either sufficient or deficient water conditions should be known throughout the growing season of plants and water-yield relationships should be formed accordingly. These data can be obtained by making a large number of investigations for each plant (Doorenbos and Kassam, 1979). To generate the data concerned, Conover (1969), Harbaugh et al. (1985), Parnell (1989), Kiehl et al. (1992), Schuch et al. (1998), Rego et al. (2004), Conte e Castro et al. (2005), Fernandes et al. (2006), Budiarto et al. (2007), Farisa et al. (2009), Waterland et al. (2010) and Villalabos (2014) made investigations on irrigation and flower quality in the chrysanthemum plant. The majority of the investigations concerned are in the form of pot studies, and they are studies in which the plant quality was determined in different soil moisture tensions. Unlike the above-mentioned studies, this study aimed to determine the effects of different irrigation intervals and water amounts on yield and

quality parameters in the chrysanthemum plant under greenhouse conditions in the Mediterranean climatic zone.

## MATERIALS AND METHODS

The research was conducted in a polyethylene-covered greenhouse of 255 (6 m x 42.5 m) m<sup>2</sup> on the Research and Application Farm of the Faculty of Agriculture at Süleyman Demirel University (lat. 37.83° N, long. 30.53° E, altitude 1,020 m) in 2011 (in Isparta, Turkey). Some characteristics of the greenhouse soil (in 0- to 50-cm depths) were as follows: texture: clay loam; bulk density: 1.32-1.41 g cm<sup>-3</sup>; field capacity: 24.80-27.01%; permanent wilting point: 7.08-8.51%, and total available water holding capacity in 0- to 50-cm soil depths: 123.6 mm (Table 1).

Table 1. Some Properties of the Soil in the Greenhouse

Soil Depth cm	Soil								
	FC		WP		BD	AWHC			
	%	mm	%	mm	g cm <sup>-3</sup>	%	mm		
0-25	24.80	81.8	7.08	23.4	1.32	17.7	58.4		
25-50	27.01	95.2	8.51	30.0	1.41	18.5	65.2		
Total		177.0		53.4			123.6		

FC: Field capacity, WP: Wilting point, BD: Bulk Density, AWHC: Available water holding capacity.

The mean daily temperature ranged from 20 to 30°C in the greenhouse but from 15 to 25°C outside the greenhouse in 2011. The relative humidity was 70-80% in the greenhouse but 50-70% outside the greenhouse (Figure 1) (DMI, 2011). Spray cut chrysanthemum (*Chrysanthemum morifolium* cv. 'Bacardi') was used as the plant material in the research. Uniform rooted cuttings were planted on 20 June 2011 into plots (1-m length, 1-m width) with five rows (20×12.5 cm spacing, 40 plants/m<sup>2</sup>), and each plot contained 40 plants. Plants were grown under long day (LD) conditions until the plant height reached 0.3 m, followed by short day (SD) period up to harvesting. SD (08:00-17:00) period was enforced by using a blackout screen (Kofranek, 1980; Kazaz et al., 2010; Lin et al., 2011). Fertilization was applied to each treatment at equal amounts as follows: (ppm): N: 200, P: 20, K: 150, Ca: 80, Mg: 25, Fe: 3.0, Mn: 0.5, Cu: 0.02, Zn: 0.05, B: 0.5, Mo: 0.01 (Yoon et al 2000). Standard cultivation practices for flower bud removal, supporting system, disease

and pest control as used for commercial standart spray cut chrysanthemum production in Turkey were employed for growing the crops during the experiment. The practice of pinching was not applied to the plants in the study.

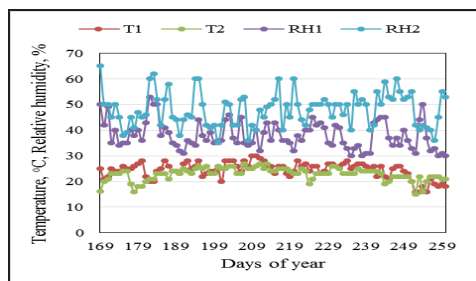


Figure 1. Temperature and relative humidity values at inside and outside of greenhouse. (T<sub>1</sub> and RH<sub>1</sub>: Temperature and relative humidity at inside of greenhouse, T<sub>2</sub> and RH<sub>2</sub>: Temperature and relative humidity at outside of greenhouse)

All the water which evaporated from Class A Pan (CAP) for 25 days after planting (DAP) was applied equally to all the treatments as irrigation water to ensure the root development and full survival of seedlings. The application of different irrigation intervals and irrigation water amounts was initiated 25 days after planting (DAP). The irrigation treatments were arranged as three different irrigation intervals (I<sub>1</sub>:2-, I<sub>2</sub>:4-, and I<sub>3</sub>:6-day) and 4 different crop-pan coefficients (T<sub>1</sub>:k<sub>cp</sub>1=1.20, T<sub>2</sub>:k<sub>cp</sub>2=0.90, T<sub>3</sub>:k<sub>cp</sub>3=0.60, and T<sub>4</sub>:k<sub>cp</sub>4=0.30). The experiment was conducted according to the randomized plots experimental design with 3 replications.

The CAP placed in the greenhouse was utilized to determine the irrigation water amounts (Allen et al., 1998). Irrigation treatments were based on the evaporation data (E<sub>p</sub>, mm) obtained from a CAP located inside the greenhouse. Irrigation water amount was calculated using Equation 1. Irrigation water was applied to each irrigation treatment by measuring it with a water meter.

$$IW = A \times E_{pan} \times k_{cp} \quad [1]$$

In the equation, IW denotes the irrigation water (mm), A the plot area (m<sup>2</sup>), E<sub>pan</sub> the amount of cumulative evaporation at the irrigation interval (mm), and k<sub>cp</sub> the crop-pan coefficient.

The irrigation applications were carried out with the drip irrigation method. The dripper and lateral space was 20 cm, whereas the

dripper discharge was 2 l/h (Uçar et al., 2011). The soil water content in the root zone of the plant was measured by means of watermarks (Irrometer, Model; Watermark200SS, USA). The watermarks were placed in the depths of 15 and 40 cm from the soil surface, with each experimental plot containing 2 watermarks. The watermarks were calibrated, and the calibration equation was found as  $P_w = 48.626 \times kPa^{-0.302}$  ( $R^2 = 0.97$ ) ( $P_w$ : Soil moisture as the percentage of dry weight; kPa: Watermark readings).

Plant water consumption was computed by using Equation 2 according to the fundamental principle of water budget by considering the soil moisture values measured before each irrigation application (Allen et al., 1998):

$$ET = I + P - RO - DP + CR \pm \Delta SF \pm \Delta SW \quad [2]$$

In the equation, ET denotes plant water consumption (mm), I the irrigation water applied (mm), P precipitation (mm), RO surface runoff (mm), DP deep percolation (mm), CR capillary rise (mm),  $\Delta SF$  subsurface runoff (mm), and  $\Delta SW$  the change in the moisture content of the root zone (mm). Precipitation (P), surface runoff (RO), capillary rise (CR) and subsurface runoff ( $\Delta SF$ ) were neglected in the calculations. The chrysanthemum plant is shallow-rooted, and its effective root depth is about 30 cm. Thus, the values of the watermark placed at the 15th cm were taken into consideration in the computations of plant water consumption, while the deep percolations were examined from the watermark at the 40th cm in depth. The moisture values above the field capacity in the root zone of the plant were considered deep percolation. When the watermark reading limit was exceeded (199 kPa), soil samples were collected from the experimental treatments and the soil moisture content was determined with the gravimetric method.

The flowers were harvested on September 15, 2011, when the flower in the middle opened completely and the surrounding flowers displayed full development. Stem length, stem diameter, stem weight, the number of flowers, vase life and root length were determined.

The obtained data were subjected to an analysis of variance by means of MINITAB 16 computer software, and the LSD Multiple

Comparison test was applied by means of MSTAT-C computer software in order to compare the averages.

## RESULTS AND DISCUSSIONS

*Irrigation Water and Evapotranspiration:* The values of irrigation water, percolated water, and plant water consumption applied according to the experimental treatments are provided in Table 2. All the water which evaporated from CAP for 25 DAP (160.3 mm) was applied to all treatments as irrigation water to ensure the root development and full survival of seedlings. During the growing period, 517.9, 428.5, 339.1 and 249.7 mm of water was applied to treatments T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, and T<sub>4</sub>, respectively. The total amount of evaporation was 458.3 mm (Table 2).

Table 2. Evaporation and irrigation water values in the treatments

Treatments	Evaporation (from CAP)	IW <sub>1</sub>	IW <sub>2</sub>	IW
T <sub>1</sub>		160.3	357.6	517.9
T <sub>2</sub>	458.3*	160.3	268.2	428.5
T <sub>3</sub>		160.3	178.8	339.1
T <sub>4</sub>		160.3	89.4	249.7

\*: 160.3 mm of evaporation had been measured before making a transition to scheduled irrigation. IW<sub>1</sub>: The irrigation water amount applied to the experimental treatments before making a transition to scheduled irrigation (mm), IW<sub>2</sub>: The irrigation water amount applied according to the  $k_{cp}$  coefficients after making a transition to scheduled irrigation (mm); IW: Total irrigation water (mm).

The values of evapotranspiration measured according to the experimental treatments are presented in Figure 2. The highest evapotranspiration took place in T<sub>1</sub> treatments, where 1.2 times the water which evaporated from the evaporation pan was applied as the irrigation water (I<sub>1</sub>T<sub>1</sub>: 560.5 mm, I<sub>3</sub>T<sub>1</sub>: 553.4 mm, and I<sub>2</sub>T<sub>1</sub>: 552.7 mm), followed by T<sub>2</sub> (I<sub>1</sub>T<sub>2</sub>: 504.6 mm, I<sub>2</sub>T<sub>2</sub>: 491.3 mm, and I<sub>3</sub>T<sub>2</sub>: 486.7 mm), T<sub>3</sub> (I<sub>1</sub>T<sub>3</sub>: 427.4 mm, I<sub>2</sub>T<sub>3</sub>: 423.1 mm, and I<sub>3</sub>T<sub>3</sub>: 415.2 mm), and T<sub>4</sub> (I<sub>1</sub>T<sub>4</sub>: 345.7 mm, I<sub>2</sub>T<sub>4</sub>: 342.5 mm, and I<sub>3</sub>T<sub>4</sub>: 340.9 mm). In the study, it is seen that the evapotranspiration varied at different irrigation intervals even if the same amount of irrigation water was applied. Since the soil surfaces of the treatments with short irrigation intervals were

continuously wet, the values of plant water consumption measured in these treatments were higher. The deep percolation values ranged from 27.72 to 18.90 mm according to the experimental treatments. Since the irrigation water amount applied at the beginning of the experiment was higher than the values of plant water consumption, the majority of deep percolation (18.90 mm) had taken place before making a transition to scheduled irrigation. After making a transition to scheduled irrigation, no deep percolation occurred in treatments T<sub>3</sub> and T<sub>4</sub> (Figure 2).

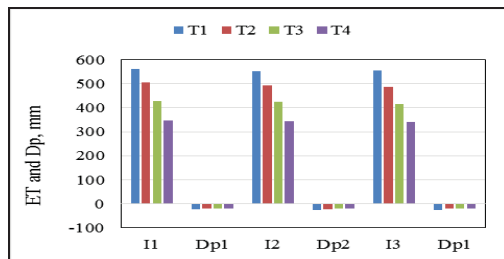


Figure 2. Evapotranspiration and deep percolation values according to the experimental treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub>: The level of irrigation water amount; I<sub>1</sub>, I<sub>2</sub> and I<sub>3</sub>: Irrigation interval; Dp<sub>1</sub>, Dp<sub>2</sub> and Dp<sub>3</sub>: Deep percolation; ET: Evapotranspiration)

**Quality Parameters:** Different irrigation intervals and irrigation water amounts significantly affected stem length, stem diameter, number of flower, stem weight, and root length at %1 level, and affected vase life at %5 level (Table 3).

**Stem length:** Growing conditions (temperature, light, photoperiod, relative humidity, CO<sub>2</sub>, and planting density) have significant effects on plant height, the number of flowers per plant, and flower size that are among the important quality criteria in chrysanthemum (Carvalho & Heuvelink, 2001). The main climatic factor used to control plant height is temperature (Carvalho et al., 2002), and the optimum temperature requirement of chrysanthemum is 18-20°C (van der Ploeg & Heuvelink, 2006). In this study, however, the temperature of the interior of the greenhouse ranged from 20 to 30°C.

The increased irrigation water amount caused significant increases in stem length. The longest stem (75.03 cm on average) was

recorded in T<sub>1</sub> treatments, to which the largest amount of irrigation water was applied, followed by T<sub>2</sub> (70.99 cm), T<sub>3</sub> (65.21 cm), and T<sub>4</sub> (57.22 cm) with the smallest amount of irrigation water application. The highest stem length in T<sub>1</sub> with the largest amount of irrigation water application was obtained from I<sub>1</sub> (79.81 cm). Stem lengths were 73.75 and 71.52 cm in I<sub>3</sub> and I<sub>2</sub>, respectively (Table 4). The differences between I<sub>1</sub> and I<sub>2</sub> and between I<sub>1</sub> and I<sub>3</sub> were statistically significant, while the difference between I<sub>2</sub> and I<sub>3</sub> was insignificant. Likewise, the longest stem in T<sub>3</sub> treatments was determined in I<sub>2</sub> (67.93 cm), followed by I<sub>1</sub> (67.18 cm) and I<sub>3</sub> (60.52 cm). Although there was a difference between I<sub>1</sub> and I<sub>2</sub>, it was not statistically significant. In T<sub>2</sub> and T<sub>3</sub>, the highest stem length was obtained from I<sub>1</sub>. When the same amount of water was applied at different irrigation intervals, its effect on stem length was not the same. This led to an interaction between the irrigation intervals and irrigation amount. The longest stem (70.96 cm) was recorded in I<sub>1</sub> with a 2-day irrigation interval, followed by I<sub>2</sub> (67.44 cm) and I<sub>3</sub> (62.94 cm). It was also stressed by Harbaugh et al. (1985) that stem length generally increased with an increase in the irrigation water amount applied. In the study concerned, they stated that the plant height was 62 cm in the treatment of 0.16 cm/day, 76 cm in the treatment of 0.24 cm/day, 86 cm in the treatment of 0.31 cm/day, 92 cm in the treatment of 0.40 cm/day, and 97 cm in the treatment of 0.47 cm/day. These data are in agreement with our results. Stem length is one of the most important indicators for the market value in chrysanthemum, as in the other cut flower species. Although varying by country, the branches which are 70-80 cm long are generally preferred in chrysanthemum (Kazaz, 2010). Chrysanthemums are classified when their flower stem lengths are 60-75 cm according to the classification in the USA but when their flower stem lengths are 50-70 cm according to the classification in England (Mengüç, 1996). All experimental treatments according to the English classification and all treatments other than I<sub>2</sub>T<sub>4</sub> and I<sub>3</sub>T<sub>4</sub> according to the American classification are included in the good class.

Table 3. The results of variance analysis of mean values of spray cut chrysanthemum quality parameters

Variation Sources	df	Mean square error					
		Stem length	Stem diameter	Stem weight	Number of flower per plant	Vase life	Root length
Replication (R)	2	19.45	0.16	74.70	6.02	5.86	0.10
Irrigation Interval (II)	2	194.22**	4.31	552.40**	54.28**	12.19*	2.96**
Irrigation water amount (IW)	3	537.44**	5.37**	8211.40**	440.99**	10.74*	38.09**
II*IW	6	22.60**	0.13**	191.80*	13.43**	4.05**	0.26
Error	22	6.03	0.12	60.0	4.00	1.89	0.41
Total	35	2307.86	28.49	28358.90	1612.22	106.22	130.97

df: degrees of freedom, \*P<0.05 and \*\*P<0.01

*Stem weight:* Stem weight ranks first among the most important quality criteria which are taken as the basis in the marketing of chrysanthemums worldwide. At the flower auction of the Netherlands (FloraHolland), the stem weights range from 45 to 105 g depending on the stem length (65, 70, and 72 cm) in spray chrysanthemums. In addition, the optimal stem weight is 70 g (Anonymous, 2010).

In terms of the irrigation water amounts, the highest stem weight was found in T<sub>1</sub> (108.72 g on average), followed by T<sub>2</sub> (83.79 g on average), T<sub>3</sub> (60.09 g on average), and T<sub>4</sub> (38.67 g on average). In terms of the irrigation intervals, the highest stem weight was obtained from I<sub>1</sub> (78.89 g on average), followed by I<sub>2</sub> (74.07 g on average) and I<sub>3</sub> (65.49 g on average). I<sub>1</sub> and I<sub>2</sub> were not statistically different in either T<sub>1</sub> or T<sub>2</sub>, ranking first and second in terms of stem weight, while I<sub>3</sub> was different (P<0.05). In a study reported concerning stem weight, Harbaugh et al. (1985) determined the plant stem weight as 93 g in the treatment of 0.16 cm/day, 127 g in the treatment of 0.24 cm/day, 138 g in the treatment of 0.31 cm/day, 149 g in the treatment of 0.40 cm/day, and 168 g in the treatment of 0.47 cm/day in different daily irrigation water applications. Higher stem weights were obtained in the treatments treated with a large amount of water in our study, which is similar to these results. It was reported that the stem weight of a chrysanthemum of a high quality ranged from 25 to 105 g according to the classification criterion of the Dutch flower auction (Anonymous, 2010), while it was reported in Japan that the chrysanthemums

which were 80-90 cm long should weigh 55-100 g (Yoon et al., 2000). Even though the stem weights in all experimental treatments are included in the good class according to the Dutch classification criterion, the stem weights of the flowers obtained from the experimental treatments other than T<sub>4</sub> are included in the good class according to the Japanese classification system.

*Number of flower per plant:* There were differences in the number of flowers in terms of both irrigation intervals and the irrigation water amounts applied. The difference between T<sub>1</sub> (28.60 flowers/plant) and T<sub>2</sub> (26.99 flowers/plant) was statistically insignificant. On the other hand, T<sub>3</sub> (20.19 flowers/plant) and T<sub>4</sub> (13.31 flowers/plant) were statistically different from each other. The differences in the number of flowers per branch between I<sub>1</sub> (24.64 flowers/plant) and I<sub>2</sub> and between I<sub>1</sub> and I<sub>3</sub> were significant, whereas the difference between I<sub>2</sub> (21.65 flowers/plant) and I<sub>3</sub> (20.53 flowers/plant) was insignificant (P<0.05).

*Vase life:* Irrigation interval and irrigation water amount had significant effects on vase life (P<0.01). The longest vase life among the irrigation intervals was determined in I<sub>3</sub> (17.82 days on average). However, the difference between I<sub>1</sub> (16.00 days) and I<sub>2</sub> (16.42 days) was insignificant. Although the difference among the irrigation water treatments was significant, there was no linear correlation either between the decrease and increase in irrigation water or between the increase and decrease in vase life. The longest vase life among all experimental treatments was recorded in I<sub>3</sub>T<sub>1</sub> (19.67 days).

Table 4. Mean values and significance groups of quality parameters of spray cut chrysanthemum

Treatments	Stem length, cm			Average	Stem diameter, cm			Average
	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>		I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	
T <sub>1</sub>	79.81 a	71.52 bc	73.75 b	75.03 A	7.69	6.77	6.68	7.05 A*
T <sub>2</sub>	74.29 b	73.57 b	65.12de	70.99 B	7.10	6.73	5.98	6.61 B
T <sub>3</sub>	67.18 d	67.93 cd	60.52 fg	65.21 C	6.74	5.78	5.72	6.08 C
T <sub>4</sub>	62.58 ef	56.73 g	52.36 h	57.22 D	6.11	5.03	4.62	5.25 D
Average	70.96 A	67.44 B	62.94 C		6.91 A	6.08 B	5.75 C	
LSD <sub>0.01</sub>	LSD <sub>I</sub> :2.079, LSD <sub>T</sub> :2.401, LSD <sub>I×T</sub> :4.158				LSD <sub>I</sub> :0.295, LSD <sub>T</sub> :0.340			
	Stem weight, gr				Vase life, day			
T <sub>1</sub>	123.61a	101.00b	101.54b	108.72 A	16.00 de	17.67a-d	19.67 a	17.78 A
T <sub>2</sub>	85.82 c	95.24bc	70.31 d	83.79 B	14.00 e	16.33 cd	17.00 b-d	15.78 B
T <sub>3</sub>	60.27 d	62.36 d	57.64 de	60.09 C	18.33 a-c	16.00 de	18.67 ab	17.67 A
T <sub>4</sub>	45.86 ef	37.69 fg	32.48 g	38.67 D	15.67 de	15.67 de	16.33 cd	15.89 B
Average	78.89 A	74.07 A	65.49 B		16.00 B	16.42 B	17.82 A	-
LSD <sub>0.01</sub>	LSD <sub>I</sub> :6.558, LSD <sub>T</sub> :7.573, LSD <sub>I×T</sub> :13.120				LSD <sub>I</sub> :1.158, LSD <sub>T</sub> :1.337, LSD <sub>I×T</sub> :2.317			
	Number of flower per plant, numbers				Root length, cm			
T <sub>1</sub>	29.41ab	26.30bc	30.09 a	28.60 A	18.93	18.57	19.54	19.01 D
T <sub>2</sub>	29.24ab	26.29bc	25.44 c	26.99 A	20.67	21.14	21.82	21.21 C
T <sub>3</sub>	23.38cd	21.20 d	15.98 ef	20.19 B	21.71	22.68	23.07	22.49 B
T <sub>4</sub>	16.53 e	12.80 fg	10.60 g	13.31 C	23.40	23.93	24.22	23.85 A
Average	24.64 A	21.65 B	20.53 B	-	21.18 B	21.58 B	22.16 A	
LSD <sub>0.01</sub>	LSD <sub>T</sub> :1.693, LSD <sub>I</sub> :1.955, LSD <sub>I×T</sub> :3.387				LSD <sub>I</sub> :0.5429, LSD <sub>T</sub> :0.6268			

\*The difference among the averages is significant at 5% level.

**Stem diameter:** Stem diameter is an important criterion for determining the resistance of a branch. In terms of the irrigation water amounts, the thickest stem occurred in T<sub>1</sub> (7.05 mm on average), followed by T<sub>2</sub>, T<sub>3</sub>, and T<sub>4</sub>. The stem diameters in these treatments were 6.61 mm, 6.08 mm, and 5.25 mm on average, respectively. When the irrigation intervals were examined, the thickest stem as found in I<sub>1</sub> (6.91 mm), followed by I<sub>2</sub> (6.08 mm on average) and I<sub>3</sub> (5.75 mm on average). The thickest stem was recorded in I<sub>1</sub>T<sub>1</sub> (7.69 mm), to which the largest amount of water was applied at a 1-day interval, whereas the thinnest stem was obtained from I<sub>3</sub>T<sub>4</sub> (4.62 mm) with the smallest amount of water application at a 6-day interval.

**Root length:** The longest root length was determined at T<sub>4</sub> (23.85 cm) which was applied the least irrigation water and also the lowest root length was determined at T<sub>1</sub> (19.01 cm) applied highest irrigation water. When the

consideration irrigation interval, the highest root length was measured I<sub>3</sub> (22.16 cm). On the contrary, other quality parameters, when the irrigation water amount and irrigation interval increased, the root length was reduced. In other words, the lowest root length was obtained from T<sub>1</sub> which had the most irrigation water amount and highest irrigation interval. It is thought, due to the plants had not water stress and could easily get water from soil, the root growth in T<sub>1</sub> was better than applied less irrigation water such as T<sub>4</sub> or T<sub>3</sub>.

## CONCLUSIONS

The irrigation water amounts applied under experimental conditions ranged from 249.7 to 517.9 mm, while the plant water consumption varied between 340.9 and 560.5 mm. The large amount of irrigation water applied increased the plant water consumption, and its effect was reflected positively on the quality parameters;

hence, a longer stem and a higher stem weight were obtained from the treatments with a larger amount of water application and high plant water consumption accordingly. In the study, the longest stem (79.81 cm), the thickest stem diameter (7.69 mm) and the highest stem weight (123.61 g) were obtained from combination I<sub>1</sub>T<sub>1</sub>, while the largest number of flowers per plant (30.09 flowers/plant) and the longest vase life were determined in combination I<sub>3</sub>T<sub>1</sub> (19.67 days). When stem length and stem weight are particularly considered in terms of marketable products, the optimum irrigation scheduling is I<sub>1</sub>T<sub>1</sub>. When it is intended to save water, treatment I<sub>1</sub>T<sub>2</sub> or I<sub>2</sub>T<sub>2</sub> might be selected as the irrigation scheduling. In this case, the reduction in flower quality will be minute.

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