International Journal of Applied Research 2022; 8(4): 380-391

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 8.4
IJAR 2022; 8(4): 380-391
www.allresearchjournal.com
Received: 04-02-2022
Accepted: 07-03-2022

Serdar Tantan
Department of Horticulture, Institute of Natural and Applied Sciences, Kocaeli University, Kocaeli, Turkey

Dr. Rezzan Kasım
Professor, Department of Horticulture, Faculty of Agriculture, Kocaeli University, Kartepe, Kocaeli, Turkey

Mehmet Ufuk Kasım
Department of Horticulture, Faculty of Agriculture, Kocaeli University, Kartepe, Kocaeli, Turkey

Corresponding Author:
Dr. Rezzan Kasım
Professor, Department of Horticulture, Faculty of Agriculture, Kocaeli University, Kartepe, Kocaeli, Turkey

Pre- and post-harvest boric acid treatments on growth, flowering and vase life in lily and gladiolus

Serdar Tantan, Dr. Rezzan Kasım and Mehmet Ufuk Kasım

Abstract
In this study, it was aimed to determine the effects of pre-and/or post-harvest boric acid treatment at two different doses (150 and 300 ppm) on the plant growth, flower quality and vase life of Belem white lily and purple flora gladiolus varieties. In the study, the lily bulbs and gladiolus corms had covered with chitosan before planting then stratification was applied at 4-5 ºC for 4 weeks lily bulbs and 6 weeks gladiolus corms. After stratification, the plants had taken to the growing condition, and boric acid was applied after leaf emerging. According to the results of the study, it was found that boric acid treatments did not any significant effect on the plant development characteristics of the white lily. However, it was determined that 300 ppm BoA treatment increased the plant height, bud diameter, number of blooming flowers, and number of the bulblet, whereas 150 ppm BoA treatment had a decreasing effect on the bottom stem diameter, the number of buds, and the amount of chlorophyll SPAD. In the gladiolus plant, while the 150 ppm BoA application caused a decrease in plant height, it was found to be effective in increasing the vase life with the periodic, cumulative, and total blooming number of flowers. For this reason, it was determined that the 150 ppm BoA treatment can be used to prolong the vase life of the gladiolus. In the study, it was found that 300 ppm BoA treatment reduced the weight loss of the flowers and increased water intake. In contrast, this application led to the lightening of the leaf color and the loss of chlorophyll, resulting in shortened vase life of the flowers. Therefore, it can be concluded that the application of 300 ppm BoA is not suitable for extending the vase life of the gladiolus.

Keywords: Boric acid, gladiolus, white lily, flower, quality, vase life

Introduction
Lily is a herbaceous flowering plant in the Liliaceae family, Lilium genus, and has different colored and pleasant flowers. While there are 250 genera and 3500 species belonging to the Liliaceae family in the world, there are 35 genera and over 400 species belonging to this family in Turkey (Arslan 2014) [1]. Lily plants spread naturally in almost all parts of the world such as Asia, Europe, and the Americas, and are used in cut floriculture, outdoors, as potted flowers, in pharmacy, and in the perfume industry. Lily is produced successfully in Europe, America, Turkey, and many countries. Lilies spp are also widely grown in the Marmara Region. (Özen *et al.* 2012) [2].
Although its flowers are not fragrant, gladiolus is an attractive plant due to its beautiful appearance and long-lasting cut flowers, easy production with low cost, easy protection from pests, different colors, long flowering period, rapid reproduction, and ease of production of new species (Sevilay *et al.* 1998) [3]. Its homeland is the tropical regions of Asia, Europe, and South Africa, and there are about 250 different species (Gürcan *et al.* 2000) [4].
Gladiolus is an important cut flower because it has a wide range of color options and the number of florets per spike is high, and it is one of the four cut flowers used in the international market. Gladiolus ranks third after carnations and roses in the cut flower trade of our country (Yalçıntaş *et al.* 2017) [5].
Boric acid is a weakly acidic boric oxide hydrate with mild antiseptic, antifungal, and antiviral properties. Although its exact mechanism of action is unknown, it is generally stated to be cytotoxic to all cells. It is also used in the treatment of yeast infections and herpes. (Anonymous 2020) [6]. In addition to these effects, boric acid is also used to increase the vase life of cut flowers. It has been determined that boric acid delays flower senescence in cut flowers by inhibiting ethylene production by decreasing the activities of ACC synthase and

ACC oxidase enzymes (Serrano *et al.* 2001) [7].

When the effects of post-harvest boric acid applications on the quality of cut flowers were examined in studies with different flowers; boric acid applications increased the vase life of flowers and the amount of TSS and decreased weight loss in the 'Nelson' clove variety (Ahmadnia *et al.* 2013) [8], decreased ethylene production in roses (Hashemabadi *et al.* 2014) [9], increased the freshness index in tuberose flowers (Khongwir *et al.* 2017) [10], increased flower diameter, water uptake, and vase life, and also maintained fresh weight in red carnations (Krishnamoorthy *et al.* 2017) [11].

However, the number of studies on the effect of boric acid applications on gladiolus cut flowers is very few, and it has been stated in the studies conducted that boric acid applications reduce the water uptake in gladiolus (Kashyap *et al.* 2017) [12] and prolong the vase life (Jian-Bo *et al.* 2009) [13], increases floret diameter and reduced the development of microorganisms in the vase solution (Khattab *et al.* 2017) [14]. However, no studies were found on garden lily.

In this study, it was aimed to determine the effects of boric acid applied during growth on plant growth and flowering in garden lily (*Lilium* spp) and the effects of pre-and postharvest boric acid treatments on plant growth and vase life in cut gladiolus (*Gladiolus grandiflorum* L. ‘Purple flora’).

Material and Method

Plant material

In this study, 'Belem' lily (*Lilium* spp. L. cv. Belem) cultivar and 'Purple Flora' gladiolus (*Gladiolus grandiflorus* L. ‘Purple flora’) cultivar obtained from the Asian Tulip Company were used as plant material.

Chemicals used in the experiment

The boric acid used in the study was obtained from Merck and chitosan from ADAGA Gıda & Danışmanlık.

Chitosan treatment and cold folding

In the study, bulbs and corms were immersed in a solution containing 1% chitosan and kept for three minutes before planting in order to prevent fungal growth. Then, bulbs and corms were planted in 10.5x13.5 sized pots containing peat:garden soil:perlite in a ratio of 2:1:1/4, with one onion or corm in each pot. After planting, the irrigated pots were kept in a cold storage at 4-5 ºC for 4 weeks for lily bulbs and for 6 weeks for gladiolus corms, and cold folding was applied. During the folding period, the pots were checked and watered regularly.

Plantation area

The pots were checked during folding, and after plant emergence began, they were placed in semi-shade conditions with sunlight, and the vegetative and generative developments of the plants were observed between March and August.

Pre-and postharvest boric acid treatments

In the experiment, boric acid was sprayed on the leaves of the plant at the doses of 150 and 300 ppm when the plant height reached 5-7 cm in the lily plant, and in gladiolus, from the emergence of two leaves. The untreated plants were used as control (K). In order to determine the effect of boric acid on vase life in gladiolus, 45 flowers from each treatment were divided into three groups after flower cutting and placed in a vase solution containing 0, 150, and 300 ppm BoA. During the life of the vase, observations, measurements, and analyzes were made at two-day intervals after harvest.

Measurements

In lily plants, total plant height (cm), flower stem length (cm), number of buds and leaves (pieces), bottom and upper stem diameter and bud diameter (mm), bulb number, diameter and weight, chlorophyll SPAD content, flower opening, and wilting time measurements were done.

In gladiolus, pre-harvest plant height (cm), flower stem length (cm), spike length (cm), floret diameter (mm), periodical floret opening time, cumulative floret opening time, wilting floret time, weight loss (%), daily and cumulative water intake (mL), vase life (days), floret and leaf color, chlorophyll SPAD amount were measured.

Experimental design and statistical analyses

Growing period experiments were established and carried out in a completely randomized plot design with 45 replications. Each plant in the treatments was evaluated as one replication.

Vase life studies in gladiolus were carried out according to a completely randomized plot design, with 15 plants in each replication for each application. Data of the study were analyzed using the SPSS 16 package program. The differences between the means were compared within 1%, 5%, and 10% error limits using the Duncan multiple comparison test.

Results

Garden Lily (Lilium spp. ‘Belem’)

Stem and total plant height (cm)

In the study, the longest stem length was measured with 15.94 cm in 300 ppm BoA, followed by 150 ppm BoA (15.46 cm) and K (15.40) treatments. Similarly, the total plant height of lilies treated with 300 ppm BoA was longer than those treated with K and 150 ppm BoA (Fig. 1). However, the difference between the treatments in terms of stem and total plant height was not significant ($p<0.05$).

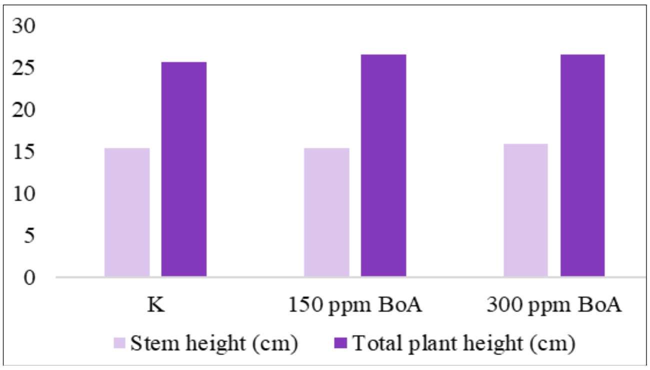

Fig 1: Flower stem and total plant height in lilies treated with different doses of boric acid. The difference between treatments is not significant

Number of leaves and buds (pieces)

In the study, boric acid treatments did not have a significant effect on the number of leaves and buds of the lily plant ($p>0.05$). On the other hand, it was determined that the number of leaves of the plants in K treatment (46.89 pieces) was higher than the flowers treated with 150 (45.96 pieces) and 300 ppm BoA (45.87 pieces). The number of buds of the lilies also showed a similar change to the number of leaves, the highest number of buds were obtained from the application of K with 5.32, while the least number of buds were obtained from the application of 5.04 and 150 ppm of BoA (Fig. 2).

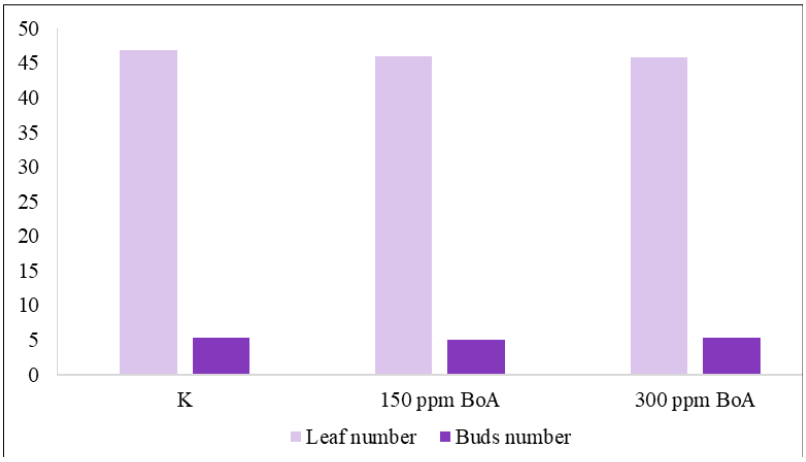

Fig 2: The number of leaves and buds in lilies treated with different doses of boric acid. The difference between treatments is not significant

The diameter of bottom and upper stem and bud

The measurement results of stem bottom diameter, upper diameter, and bud diameter of lily plants are given in Fig. 3. Accordingly, the bottom and upper stem diameters of lily flowers in the K treatment were found to be wider than the samples applied 150 and 300 ppm BoA. However, the difference between K and 150 ppm BoA in terms of stem bottom diameter was found to be statistically significant ($p<0.05$), while the difference between treatments in terms of trunk upper diameter was not statistically significant ($p>0.05$). In the study, the highest bud diameter was measured in lily plants treated with 300 ppm BoA with 13.78 mm and followed by 150 ppm BoA (13.23) and K (12.92 mm) treatments. Also, the differences between 300 ppm BoA and K treatments were significant statistically at the level $p<0.05$.

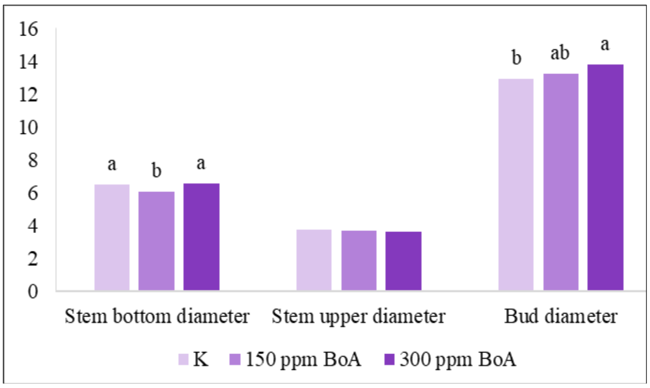

Fig 3: The stem bottom, upper and bud diameter of lily plants treated with different doses of boric acid. The differences among treatments in terms of stem upper diameter is not significant.

The number, diameter ve weight of bulblets

In the study, although 300 ppm BoA treatment slightly increased the number of bulblets (2.38) compared to K (2.31 units) and 150 ppm BoA (2.04 units), there was no statistically significant difference ($p>0.05$) between applications (Fig.4). When the bulblet diameter data were examined, it was observed that the bulblets diameter (34.38 mm) of the plants in the K treatment was larger than those in the application of both 150 ppm BoA (33.21 mm) and 300 ppm BoA (33.03 mm) (Fig. 4). Although the 150 ppm BoA (34.90 g) was more effective than the other two treatments in terms of bulblets weights, there was no statistically significant difference ($p>0.05$) between applications.

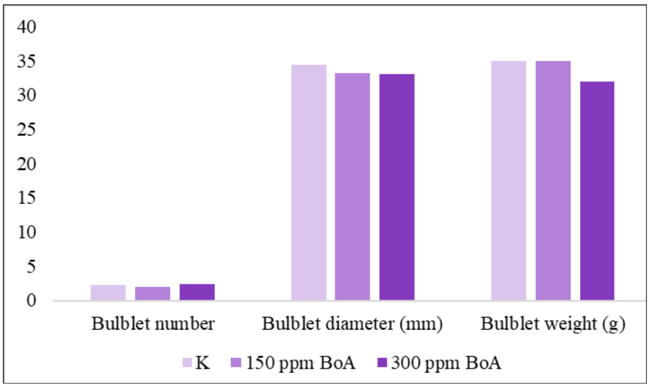

Fig 4: The number, diameter, and weight of bulblets in lily plants treated with different doses of boric acid. The difference between applications is not significant.

The chlorophyll SPAD content

In the research, it was observed that different boric acid applications did not have a significant effect on the chlorophyll SPAD amount of the leaves during plant development ($p>0.05$) (Fig. 5). However, the amount of chlorophyll SPAD, which was higher in the K (49.93) application at the beginning of the study than in both boric acid treatments (48.61 and 48.42 for 150 and 300 ppm BoA, respectively), decreased on the seventh day in the K group and increased in boric acid treatments. At the end of the experiment, the amount of chlorophyll SPAD was highest in the K, whereas it was the lowest in the 150 ppm BoA treatment.

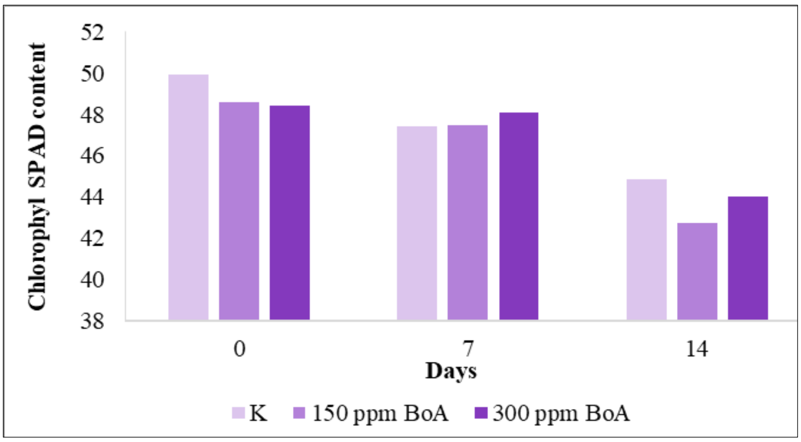

Fig 5: Changes in the amount of chlorophyll SPAD in the leaves during the experiment in lily plants treated with different doses of boric acid. The difference between treatments is not significant

Blooming time

In the experiment, the day when the lily plants in the cultivation area started to bloom was considered zero, and the data related to flowering were evaluated accordingly (Fig. 6). Accordingly, plants in K treatments bloomed more than those treated with boric acid until the sixth day of the experiment. Blooming was the highest in plants treated with 300 ppm BoA from the eighth day onwards 300 ppm and also on the 16th day 150 ppm BoA bloomed more than the others. However, it was determined that the effect of boric acid applications on flowering was statistically insignificant ($p>0.05$) except for the 12th day, and there was a significant difference between 300 ppm BoA application and 150 ppm BoA and K applications on the 12th day.

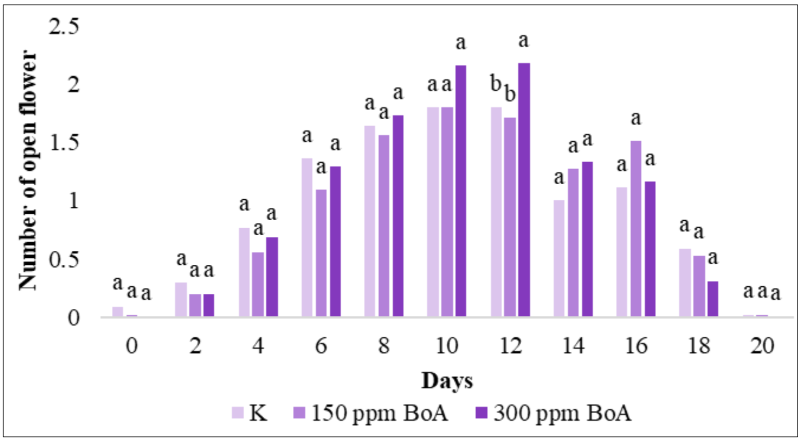

Fig 6: Flowering times of lily plants treated with different doses of boric acid during the experiment

Wilting time of flowers

In the study, it was determined that the flowers blooming on lily plants started to wilt from the sixth day of flowering (Fig. 7). In general, it is seen that the wilting time of flowers in 300 ppm BoA treatment is longer than flowers in K and 150 ppm BoA application. On the other hand, it was determined that there was no significant difference between the applications until the 14th day of the development period, but there was a statistically significant difference ($p<0.05$) between 150 and 300 ppm BoA applications on the 16th and 18th days.

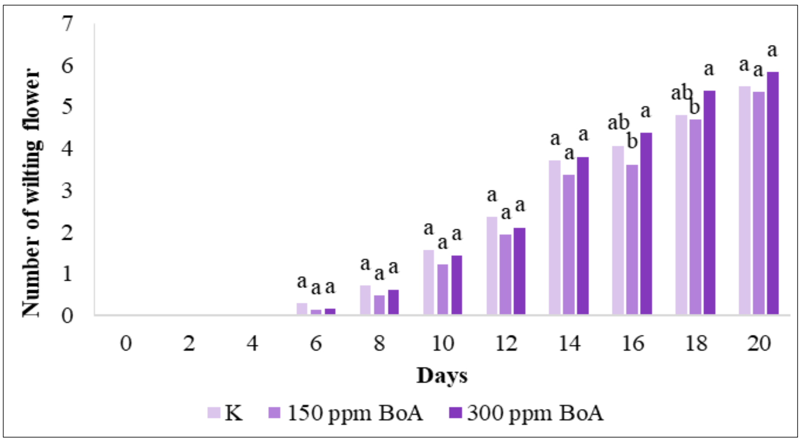

Fig 7: Wilting times of flowers in lily plants treated with different doses of boric acid

Gladiolus (*Gladiolus grandiflorus* L. cv. Purple Flora)
Hasat öncesi bitki boyu

In the study, the day when plant height measurement was done on the 'Purple flora' gladiolus plants in the cultivation area was taken into as beginning of experiment (Fig. 8). Accordingly, it was determined that overall plant height increased in all applications, whereas the highest increase was in the plants in the control group, followed by 300 and 150 ppm BoA treatments. However, it was found that the effect of boric acid applications on plant height was not significant except for the sixth day, and the difference between K and 150 ppm BoA on the sixth day was statistically significant (p<0.10).

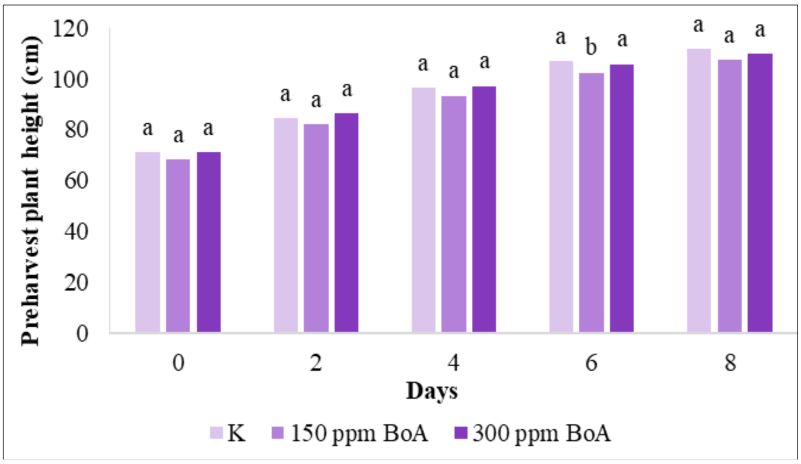

Fig 8: Changes in plant height during development in gladiolus plants treated with different doses of boric acid before harvest

Flower stalk and spike height and floret diameter

In the study, gladiolus flowers were harvested with the leaves when the color was seen in the first floret in order to carry out post-harvest studies. In the study, it was determined that the stem length of gladiolus flowers in the K application was the longest with 92.77 cm, followed by 300 ppm BoA (91.96 cm) and 150 ppm BoA (88.84 cm) treatments (Fig. 9). However, there was no significant difference between K and 300 ppm BoA applications, while the difference between K and 150 ppm BoA was statistically significant (p<0.05). Similar results were obtained in terms of spike length, and the spike length of gladiolus flowers (34.84) in the K application was found to be significantly longer (p<0.05) than in other applications. In the study, floret diameter (52.53cm) in flowers treated with 150 ppm BoA increased slightly compared to K (51.07 cm) and 300 ppm BoA (50.25 cm), but there was no statistically significant difference between the applications (Fig 9).

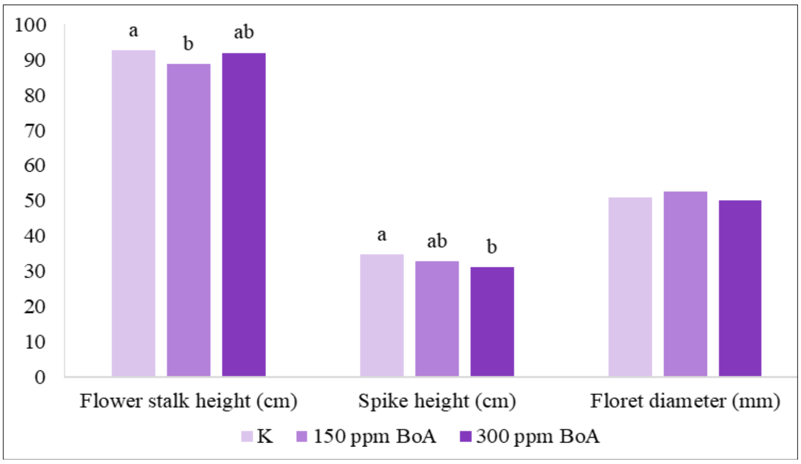

Fig 9: Flower stem and spike length and floret diameter in gladiolus treated with different doses of boric acid before and after harvest. The differences among treatments in terms of flower diameter is not significant

Periodic opened floret number

In the study, more florets bloomed in the control group at the beginning and on the fourth day of vase life. On the other hand, 150 ppm BoA application came to the fore on the second, eighth and tenth days (Fig. 10). In addition, 300 ppm BoA application was more effective on the opening of flowers on the sixth day of vase life. As a result of the statistical evaluation, a statistically significant difference at p<0.05 level was found between K and 150 ppm BoA and 300 ppm BoA on the second day of storage and between 150 ppm BoA and K and 300 ppm BoA on the eighth and tenth days.

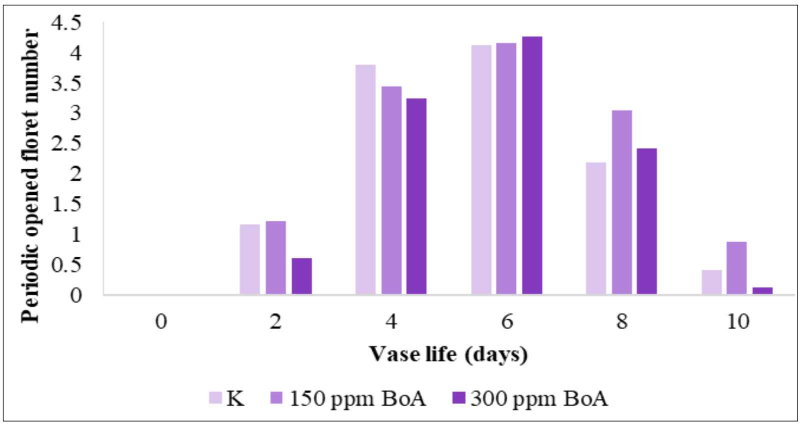

Fig 10: Periodic opened flower number during vase life in gladiolus flowers treated with different doses of boric acid before and after harvest. The differences among the treatments is not significant

Cumulative number of opened floret

The cumulative total floret opening in the gladiolus spikes in the experiment is given in Fig. 11. Accordingly, in the study, the number of blooming flowers in gladiolus treated with K and 150 ppm BoA increased in parallel with the increase in vase life, and this increase was found to be statistically significant compared to 300 ppm BoA application on the sixth, eighth and tenth days of vase life.

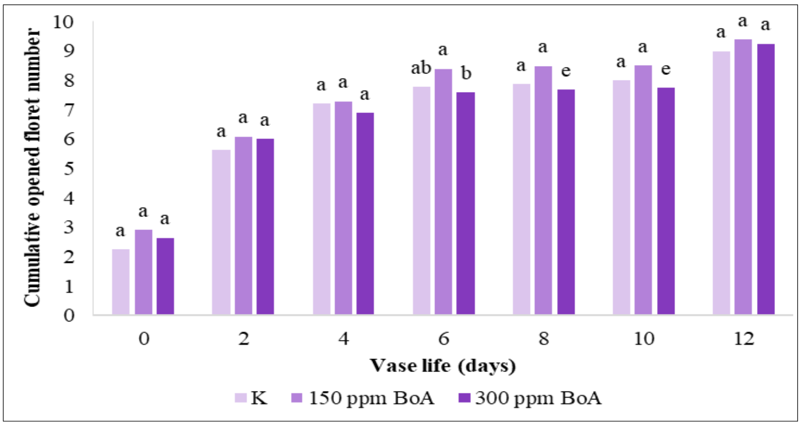

Fig 11: Cumulative opened flored number during vase life in gladiolus treated with different doses of boric acid before and after harvest

Total number of opened floret

In the study, the highest opened floret number (12.73) was detected in gladiolus treated with 150 ppm BoA, followed by K (11.67 units) and 300 ppm BoA (10.67 units). In this respect, the difference between 150 ppm BoA and K applications was found to be significant at the $p<0.05$ level (Fig. 12).

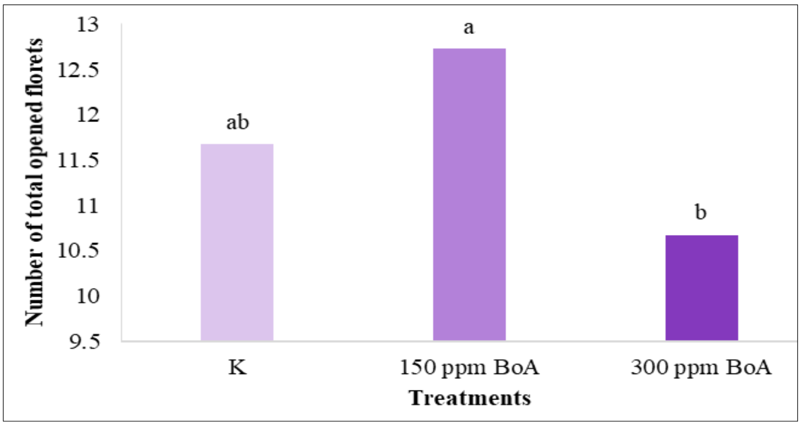

Fig 12: Hasat öncesi ve sonrası farklı dozlarda borik asit uygulanmış ‘Purple flora’ glayöl çeşidinde vazo ömrü sonunda toplam açan kandil sayısı

Wilted floret number

In the study, the opened florets in gladiolus started to wilt from the fourth day of their vase life (Fig. 13). In the experiment, on the sixth, eighth and tenth days of the vase life, the number of wilted florets in the K group was higher than in the samples treated with 150 and 300 ppm BoA. On the other hand, on the fourth, 12th, and 14th days of vase life, more florets wilted than in the other two treatments in the 150 ppm BoA group. However, the difference between K and 300 ppm BoA on the sixth and eighth days of vase life, and the difference between 150 and 300 ppm BoA on the 12th and 14th days of the vase life were statistically significant ($p<0.05$).

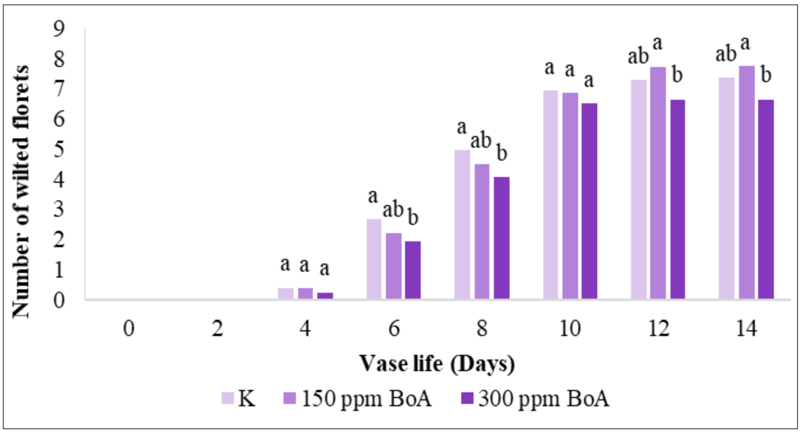

Fig 13: Number of withered florets during vase life in gladiolus flowers treated with different doses of boric acid before and after harvest

Weight loss

In the experiment, weight gain occurred as a result of the flowers absorbing water on the second day of the vase life, but the weight loss of gladiolus flowers increased from the fourth day (Fig. 14). In addition, it was determined that both boric acid treatments were significantly ($p<0.05$) effective in reducing weight loss from the sixth day of vase life compared to the control.

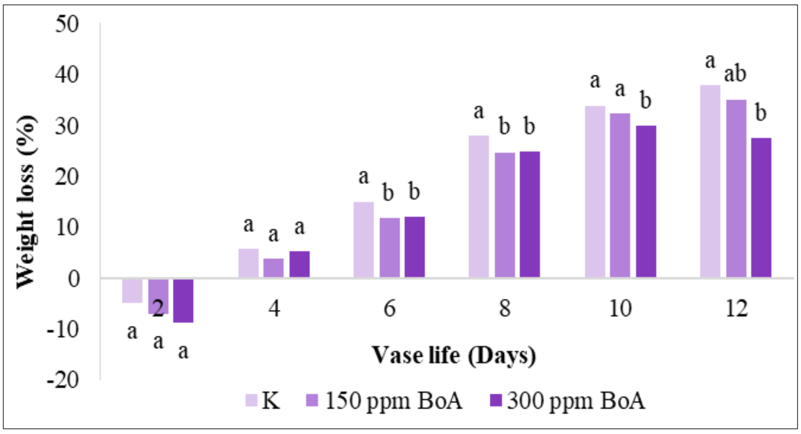

Fig 14: Weight losses during vase life in gladiolus flowers treated with different doses of boric acid before and after harvest

Daily water intake

In the study, it was found that the daily water intake of gladiolus flowers decreased inversely with the increase in vase life (Fig. 15). In general, the daily water consumption of gladiolus flowers in group K during the vase life was higher than the other treatments, only flowers that were applied 300 ppm BoA on the fourth and sixth days consumed more water daily. However, it was determined that there was a statistically significant ($p<0.05$) difference between 150 and 300 ppm BoA applications on the fourth, sixth, and eighth days of the vase life, and between K and 300 ppm BoA on the tenth day.

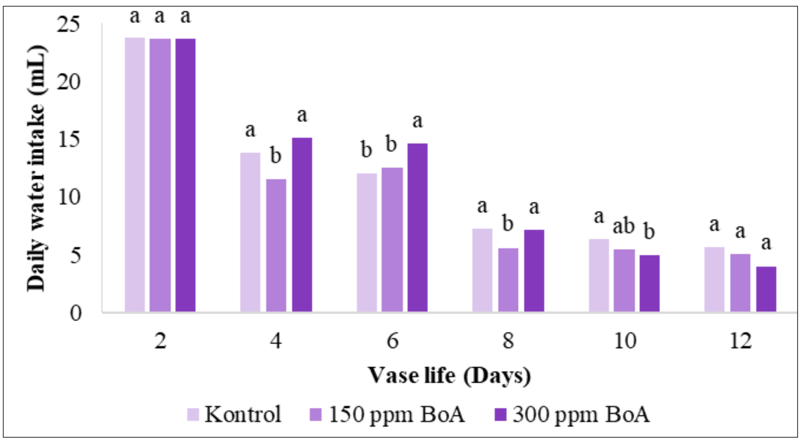

Fig 15: Changes in daily water intake during vase life in gladiolus flowers treated with different doses of boric acid before and after harvest

Cumulative water intake

Cumulative water uptake of gladiolus flowers increased overall over the vase life (Fig. 16). In the experiment, it was determined that the water intake of the flowers in the 300 ppm BoA treatment was higher than the K and 150 ppm BoA applications. In addition, the difference between 150 and 300 ppm BoA on the sixth, eighth and tenth days of vase life was statistically significant ($p<0.05$) in terms of water uptake.

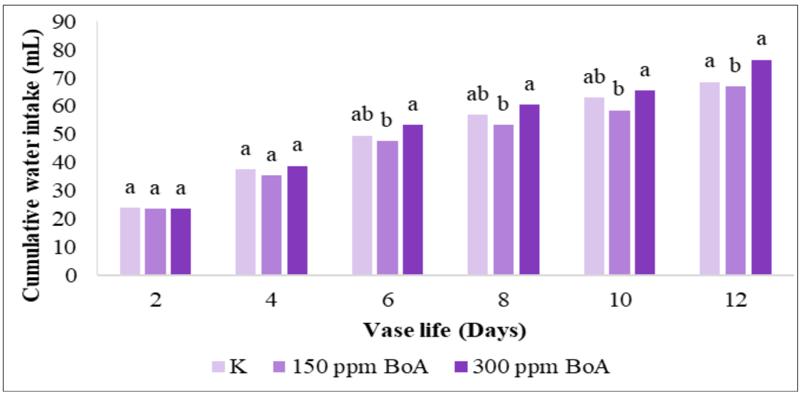

Fig 16: Changes in cumulative water uptake during vase life in gladiolus flowers treated with different doses of boric acid before and after harvest

Vase life

In the study, the highest vase life (12.02 days) in gladiolus cut flowers was obtained in the 150 ppm BoA group, followed by K (11.56 days) and 300 ppm BoA (11.13 days) applications. In addition, the difference between 150 ppm BoA and K and 300 ppm BoA applications in terms of vase life was found to be statistically significant ($p<0.05$) (Fig. 17).

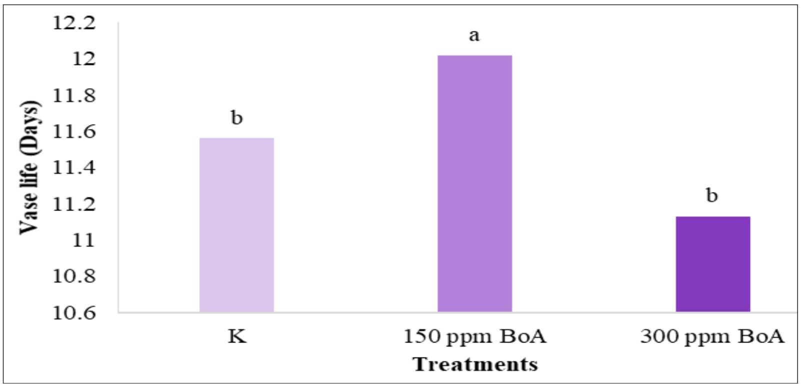

Fig 17: Vase life of gladiolus flowers treated with different doses of boric acid before and after harvest

Color of florets

In the study, it was determined that the L* value of florets in the K treatment was higher than in both boric acid applications. In the experiment, the highest *a** value was measured from the gladiolus florets in the 300 ppm BoA group, and the lowest value was from the florets in the K application (Fig. 18). However, it was determined that there are no statistically significant differences between the treatments in terms of *L** and *a** color values. Although the *b**, hue *(h°)*, and chroma color values measured in the study showed similar changes, the difference in hue angle between K and 300 ppm BoA applications was statistically significant ($p<0.10$).

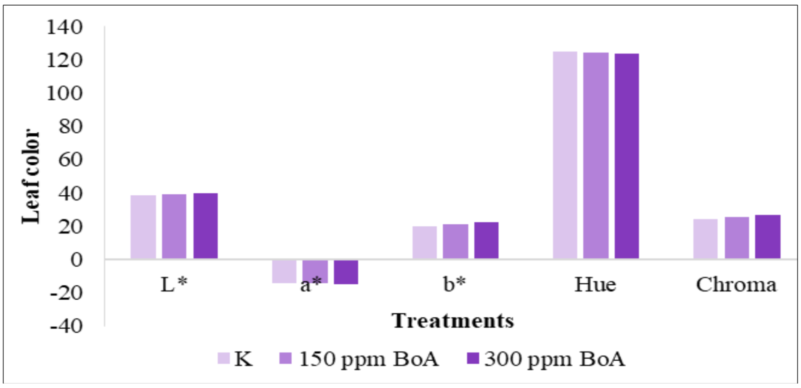

Fig 18: Color data of florets in gladiolus flowers treated with different doses of boric acid before and after harvest. The differences among treatments is not significant

Leaf color

In the study, the *L** value of gladiolus leaves treated with 300 ppm BoA was found to be significantly higher than in the other two applications ($p<0.05$). In the study, it was determined that the *a**, hue, and chroma values of the leaves changed similarly, and these parameters were higher in gladiolus leaves in group K than in the other two applications (Fig. 19). The *b** color value of the leaves showed a similar change to the *L** value, and the highest *b** value was measured in 300 ppm BoA (22.17) application, while the lowest value was found in the K group with 20.15. In addition, it was observed that there was a statistically significant ($p<0.01$) difference between the applications in this respect.

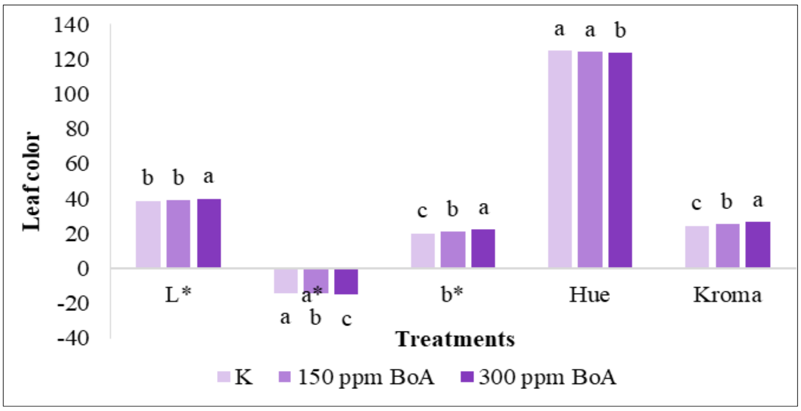

Fig 19: Color data of gladiolus leaves treated with different doses of boric acid before and after harvest

Chlorophyll SPAD content of leaves

In the study, the lowest amounts of chlorophyll SPAD in gladiolus leaves during their vase life were obtained from leaves treated with 300 ppm BoA, followed by 150 ppm BoA and K applications (Fig. 20). In addition, the difference between K application and 150 ppm BA and 300 ppm BA applications was found to be statistically significant ($p<0.05$) until the tenth day of vase life.

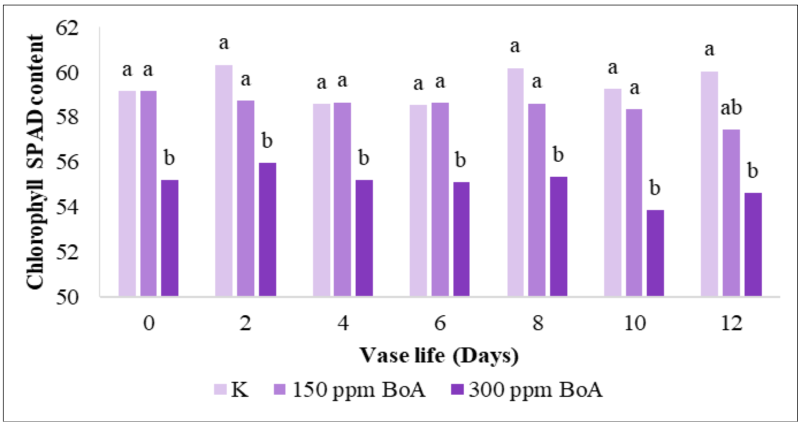

Fig 20: Chlorophyll SPAD amount of gladiolus leaves treated with different doses of boric acid before and after harvest

Cormlet number, diameter and weight

In the study, although 150 and 300 ppm BoA applications increased the number of cormlets slightly, the diameter and weight of these were lower than the control group. In this respect, the difference between the applications was also found to be insignificant ($p>0.05$).

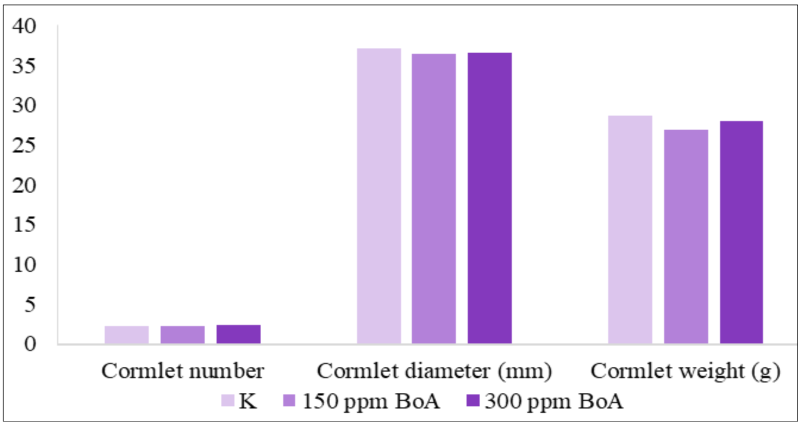

Fig 21: The number, diameter, and weight of cormlets of gladiolus treated with different doses of boric acid before and after harvest. The differences among treatments is not significant

Discussion

In this study, the effects of applying two different doses of the boric acid solution, 150 and 300 ppm, to the leaves of the 'Belem lily' cultivar until flowering, on the flower quality were investigated; In the 'Purple flora' gladiolus cultivar, the effects of boric acid applied to both pre-harvest leaves and post-harvest vase solution on pre-harvest plant growth and post-harvest vase life were tried to be determined.

Although boric acid has antiseptic, antifungal, and antiviral properties, it is defined as weakly acidic boric oxide hydrate, which is also used in the treatment of yeast infections and herpes, but its mechanism of action is not known exactly (Anonymous, 2020) [6]. However, due to its inhibitory effect on ethylene production, it has been used to extend the vase life of cut flowers in recent years (Serrano *et al.* 2001) [7].

In the study, although the different doses of boric acid treatments to the 'Belem lily' plant did not have a significant effect on the total height and stem height of the plant, it can be said that, in general, 300 ppm BoA treatment has an enhancing effect on the plant height compared to 150 ppm BoA and K applications. In the study in which the effect of different planting densities on the onion development of Lilium spp. L was investigated, the plant height was found to vary between 38.07-39.50 cm (Kahraman 2015) [15], but the plant height was determined to be at most 26.56 cm in the current study. The difference between these two studies was thought to be due to the cultivation of lilies in pots in the current study.

Although boric acid increased the height of lily plants, it caused a decrease in the lower and upper diameters of the stem. The stems of the plants in the control group were wider. In a study by Kahraman (2015) [15], it was found that the stem diameter of 'Belem lily' plants grown using different planting spacing and distances varied between 7.03-7.33. In the present study, the lowest stem diameter of the 'Belem lily' plants grown in pots was 150 ppm BA (6.06 mm), and the highest was determined in the K (6.48 mm) application. It was thought that the low stem diameters were the result of growing the plants in pots.

Although 300 ppm BA application had an effect on increasing plant height, when the subject was examined in terms of the number of buds and leaves, the higher number of buds and leaves in the plants in the control group showed that boric acid had a reducing effect on bud formation. The fact that the number of buds of the plants in boric acid applications was less, caused these buds to be larger.

Although it was found that boric acid applications did not have a significant effect on the number, diameter, and weight of the bulb onions, 300 ppm BoA application increased the number of bulblets. In a study, the effects of bulb planting density on bulb development in the 'Belem lily' plant were investigated, and as a result of the research it was found that bulb diameters ranged between 5.90-5.94 cm, and bulb weights varied between 70.92-79.29 cm (Kahraman 2015) [15]. Bulb diameter and weights obtained in the present study were lower than in this study. The reason for this is thought to be due to the fact that the plants did not flower due to the investigation of onion development in the study, and that the onions developed more.

In the study, it was determined that boric acid treatments did not have a significant effect on the amount of chlorophyll SPAD. However, 300 ppm BoA increased the blooming time of lily plants, and this effect was found to be statistically significant, especially 12 days after the flowers opened. In addition, the number of wilting flowers in this application was higher than in others.

In the current study, boric acid applications showed a plant height-reducing effect in 'Purple flora' gladiolus plants, similar to lilies. During the experiment, the height of the plants in the K application was longer than the plants in the 300 and 150 ppm BoA applications. Similar results were obtained in flower stem measurements, while the flower length of the plants in K application was 92.77 cm, it was measured as 91.96 cm and 88.84 cm in 300 and 150 ppm BoA applications, respectively. Similar results were obtained in terms of spike sizes. Therefore, it can be stated that both 150 and 300 ppm boric acid treatments reduce plant height in both lily and gladiolus flowers.

When the periodic and cumulative floret opening times were examined in the study, it was found that the 150 ppm BoA treatment, especially on the second and sixth days of the vase life, increased the number of periodically blooming flowers and it was also found that the number of cumulative blooming flowers during the vase life was higher in 150 ppm BoA application than in other applications, and in addition, this effect was statistically significant compared to 300 ppm BoA application on the sixth day of the study. Similar results were obtained from the measurements of the total number of florets. Therefore, it was determined in the study that especially 150 ppm BoA application accelerated the opening of florets. In the experiment, it was also determined that 150 ppm BoA treatment increased the floret diameter of gladiolus plants compared to 300 ppm BoA, therefore it can be said that 150 ppm BoA treatment had a positive effect on both floret opening time and size. As a matter of fact, it was determined by Khalifa *et al.* (2011) [16] in the iris and by Hashemabadi *et al.* (2014) [9] in the rose plant that boric acid applications increased the total blooming time. In the present study, it was determined that boric acid, especially 150 ppm dose, had significant effects in this respect in gladiolus plant.

Since cut flowers maintain their vitality after harvest, their weight also decreases during their vase life. Therefore, reducing weight loss means increasing flower vase life. In the present study, when the effects of different boric acid doses on weight loss were examined, it was found that the weight loss of gladiolus flowers increased during the vase life; however, it was determined that the least weight loss was at 300 ppm BoA treatment, followed by 150 ppm BoA and K. When the daily and cumulative water intake of the flowers was evaluated, it was seen that the daily water intake of the flowers applied 300 ppm BoA was higher than the flowers in the other applications until the eighth day of the vase life, and the cumulative water intake until the end of the vase life. Therefore, the high water intake of these flowers resulted in less weight loss. In a study conducted with the 'Nelson' cut clove variety, it was determined that the least weight loss was obtained in the application of boric acid at a concentration of 200 mg/L (Ahmadnia *et al*. 2013) [8]. Similar results were obtained in this study.

Long vase life is an important quality criterion for cut flowers. The long vase life of the flowers is also related to the opening rate at the time the flower is harvested, and in general, the vase life of the plants that form a single flower on a stem is less than the flowers with the spike flower structure. Because the flowers with spike flower structures are cut after the first floret of the spike is colored, the time elapsed until all the floret on the spike bloom may be longer than those with single blooms on a stem (Ravanbakhsh *et al.* 2017) [17]. In the study, it was determined that the application of 150 ppm BoA (12.02 days) was more effective than 300 ppm BoA in prolonging the vase life. In the previous studies, it found that boric acid treatments increased the vase life by 13.5-14 days in gladiolus varieties (Jian-Bo *et al.* 2009[13]; Kashyap *et al.* 2017[12]), 8.3 days in cloves (Ibrahim and Al-Atraji 2015) [18], and 10 days in jasmine (Suntipabvivattana *et al.* 2017) [19]. Mevcut çalışmada 150 ppm BoA vazo ömrünü uzatmada etkili olurken, 300 ppm BoA azaltıcı etki göstermiştir.

In this study, the highest *L** value was measured in the floret of gladiolus spikes in the K group, which shows that its brightness increased, in other words, lightening in color occurred. In the study, 300 ppm BoA treatment increased the *a**, *b**, hue angle, and chroma values of the flowers. It was determined that 300 ppm BoA treatment increased the *L**, *b**, and chroma values of the leaves, whereas decreased the *a** and h^o values. Therefore, the application of high doses of boric acid caused the leaves to be lighter green, while at the same time increasing their brightness. As a matter of fact, the chlorophyll SPAD measurement results also supported the color data, and the chlorophyll SPAD amount of the gladiolus leaves applied 300 ppm BoA was significantly lower than the other two treatments. For this reason, both color measurements and chlorophyll SPAD results showed that 300 ppm BoA application caused the decomposition of chlorophyll and caused lightening in leaf color.

In the study, it was determined that boric acid treatments increased the number of cormlets, whereas decreased their diameter and weight.

Conclusion

In this study, it was tried to determine the effects of boric acid application at two different doses, 150 and 300 ppm, on the flower development of the 'Belem lily' plant and the plant quality and vase life in gladiolus. For this purpose, boric acid was applied to the cultivar 'Belem lily' during plant development, and to the cultivar 'Purple flora' both from leaves during plant development and as a vase solution.

When the findings were evaluated collectively, it was determined that although boric acid applications did not have a significant effect on the development of the plant in the 'Belem lily' plant, 300 ppm BoA application affected increasing the plant height, bud diameter, flowering time, and the number of bulblets. On the other hand, it was found that 150 ppm BoA treatment had a decreasing effect on stem lower diameter, the number of buds, and the amount of chlorophyll SPAD. Therefore, although the effects of boric acid doses on different properties of the plant in the 'Belem lily' plant were different, it was determined that it did not show a significant effect. Therefore, it was concluded that higher doses should be investigated for the lily plant.

In gladiolus, 150 ppm BoA application caused a decrease in plant height, bulblet diameter, and weight, while it was effective in increasing the number of periodic, cumulative, and total blooming flowers and vase life. In the study, it was determined that 300 ppm BoA treatment decreased the diameter of the florets and weight loss while increasing the total water uptake, but causing leaf discoloration and chlorophyll fragmentation. In addition, 300 ppm BoA treatment also increased the number of cormlets.

As a result, it was determined that 150 ppm BoA treatment could be used in terms of prolonging the vase life in gladiolus. However, the fact that 300 ppm BoA application decreased the weight loss of flowers and increased water intake was considered a positive effect, but it was thought that this application decreased the vase life since it caused leaf color to lighten and chlorophyll loss. For this reason, it was concluded that 200 ppm dose in gladiolus should also be examined in further studies.

Acknowledgement

We would like to thank Kocaeli University BAP Coordination Unit (Project No: 2019/053) for supportingthis master's thesis study

References

1. Arslan M, Ordu İlinde Doğal Olarak Yetiştirilen Bazı Zambak Genotiplerinin (*Lilium* spp). Belirlenmesi Üzerine Bir Araştırma, Fen Bilimleri Enstitüsü Bahçe Bitkileri Anabilim Dalı, Yüksek Lisans Tezi, 2014, 136.
2. Özen F, Temeltaş H, Aksoy Ö. The Anatomy and morphology of the medicinal plant, *Lilium candidum* L. (Liliaceae), Distributed in Marmara Region of Turkey, Pak. J Bot. 2012 Apr;44(4):1185-1192.
3. Sevilay N, Bahar G, Korkut AB. Bazı glayöl çeşitlerinde dikim sıklıklarının korm ve kormel verimine etkileri üzerine bir araştırma, Turk J Agric For. 1998;22:51-58.
4. Gürcan Ö, Türkoğlu N. Bazı glayöl çeşitlerinde kesme çiçek ve soğanımsı yumru gelişimi. Agric. Sci. 2000;10(1):1-6.
5. Yalçıntaş C, Ellialtıoğlu Ş, Gümüş C. Ankara koşullarında açıkta yetiştirilen glayöl (*Gladiolus grandiflorus*) çeşitlerinin bazı bitki gelişim özellikleri bakımından incelenmesi. TURKJANS. 2017;4(2):236-244.
6. Anonymous [Internet] Boric Acid. U.S. National Library of Medicine, National Center for Biotechnology Information. 2020 [cited 2020 Feb 02]. Available from: https://pub chem.ncbi.nlm.nih.gov /compound/Boric-acid;
7. Serrano M, Amorós A, Pretel, MT, Madrid MCM, Romojaro F. Preservative solutions containing boric acid delay senescence of carnation flowers. Postharvest Biol. Technol. 2001;23(2):133-142.
8. Ahmadnia S, Hashemabadi D, Sedaghathoor S. Effects of boric acid on postharvest characteristics of cut carnation (*Dianthus caryophyllus* L. cv. 'Nelson'), Ann. Biol. Res. 2013;4(1):242-245.
9. Hashemabadi D, Liavali MH, Kaviani B, Mousavi M, Keyghobadi S, Zahiri S. Effect of nano-silver and boric acid on extending the vase life of cut rose (*Rosa hybrida* L.). J Environ. Biol. 2014;35(5):833-838.
10. Khongwir NKL, Singh MC, Singh Krishan P, Ajay A. Postharvest quality of tuberose (*Polianthes tuberosa*) loose flower as affected by elicitor treatment. Progressive Horticulture. 2017;49(1):69-74.
11. Krishnamoorthy C, Mythilipriya V, Poovarasan G, Sangavi S. Influence of post-harvest chemical treatments on shelf-life of carnation (*Dianthus caryophyllus* L.), Agriculture Update (Techsear-1). 2017;12:92-96.

12. Kashyap S, Shukla N, Ramteke V, Shukla A. Influence of citric acid, boric acid and salisylic acid on vase life of cut spikes of gladiolus (*Gladiolus Grandiflorus* L.). TIBS. 2017;10(25):5354-5355.
13. Jian-Bo B, Yin-li Z, Bing L, Yan-gang L. Study on the preservative effects of boric acid & ethanol on cut gladiolus, Biological Sciences & Technology Institute, 2009.
14. Khattab M, Torky EM, Torabeih AE, Rashed H. Effect of some chemicals on vase life of gladiolus cut flowers, Alex. Sci. Exch. 2017;38(3):588-598.
15. Kahraman Ö. Beyaz zambak soğan performası üzerine dikim sıklığının etkisi. Anadolu J Agr Sci. 2015;30:95-98.
16. Khalifa RKHM, Shaaban SHA, Rawia A. Effect of foliar application of zinc sulfate and boric acid on growth, yield and chemical constituents of iris plants. Ozean J Appl. Sci. 2011;4(2):2011.
17. Ravanbakhsh A, Mobasser HR, Hasandokht MR. Effect of ascorbic acid and acetyl salicylic acid on the quality and vase life of cut flowers gladiolus (*Gladiolus persicus*). Int. J Agric. Biosci. 2017;6(1):31-33.
18. Ibrahim MMA, Al-Atraji AOA. Effect of boric acid on flowers longevity of two *Dianthus caryophyllus* L. DASJ. 2015;7(1):102-110.
19. Suntipabvivattana N, Tongdeesuntorn W. Shelf-life extending of jasmine garland. Acta Hortic. 2017;1167:419-424.