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IMPACT OF GIBB A3 ON GROWTH PERFORMANCE OF TWO *EUSTOMA GRANDIFLORUM* VARIETIES

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Abstract

Eustoma grandiflorum (Raf.) Shinners has a significant role in the cultivation of ornamental plants, appearing as cut or sometimes potted ornamental plants. Commercial growers of ornamental plants incorporate plant growth regulators into their cultural practices. These regulators significantly affect both vegetative growth and flower yield in flowering crops. Notably, gibberellic acid is essential for improving flower production, quality, and yield in these crops. The aim of the study was to determine whether different concentrations of growth stimulators, notably GIBB A3, have a positive or negative effect on the production of cut flowers of two Lisianthus (Eustoma grandiflorum `Croma lavender` and E. grandiflorum `Rosita yellow`). `Croma lavender` has thick, strong petals and characteristic extra-double flowers, and `Rosita yellow` has double-flowered inflorescences, thick petals, and strong stems. GIBB A3 was applied to the plants as a foliar fertilizer. During the experiment, the following treatments were used: control (seedlings did not receive any treatment), 25, 50, 100 and 150 mg/L of GIBB A3. Each treatment was carried out in four replicates, with each replication containing 10 individual plants. The growth of the two varieties, including the length and number of shoots, stem diameter, bush diameter, number of flowers, and flower diameter, were measured and recorded during the experiment. Results indicated that the plants treated with 150 mg/L concentration of GIBB A3 reached the expected outcomes. Further more, when comparing the control to the treated plants, statistically significant differences were determined for all the measured parameters. Also, significant differences were observed between the two studied Lisianthus varieties. From the results, it could be concluded that the GIBB A3 treatments positively influenced the flowering and development of the two Lisianthus varieties.

Key words*: cut flowers, growth hormones, GIBB A3, Lisianthus.*

INTRODUCTION

One of the most significant segments of the horticulture industry is undoubtedly floriculture, which produces a wide variety of products (Traversari et al., 2021), such as bedding plants, garden plants, indoor and outdoor plants, and cut flowers and greens (Wani et al., 2018). The floriculture industry is one of the most inventive segments of the plant cultivation industry, and its inventions are frequently applied to other horticultural fields (Volckaert et al., 2010).

The *Eustoma grandiflorum* (Raf.) Shinners is generally a new floriculture crop on the global market, which quickly ranked among the top ten cut flowers due to its excellent post-harvest life (Harbaugh, 2007; Castillo-González et al., 2018), which generally can range between 12-25 days (Jamal Uddin et al., 2013), other authors are mentioning approximatively 15 days when stems are properly handled (Chuang & Chang, 2013). Its origin is from North America, but it was bred in Japan, and since then it has become more and more popular worldwide (Powo). According to Stock et al. (2022) the Lisianthus blooms from June through October with multiple branching stems. Worldwide, 48 colors of flower variety can be found (white, pink, violet, white pink, lavender, etc.), moreover there can be found both single and double flower (Uddin et al., 2015; Fatima et al., 2022).

Growth, yield, and flowering can be enhanced by the use of growth hormones; however, in the case of the quality of flower production, the concentration of hormones and the time of application are of utmost importance, or else it will lead to an undesirable effect (Javid et al., 2022). However, it is also stated that growth hormones can have a positive influence on the quality and production of cut flowers (Rademacher, 2015). Campos-Rivero et al. (2017), reported that plant hormones such as

GA, abscisic acid, jasmonic acid, and auxins have crucial effects on flowering. Plant hormones are involved in the regulation of flower senescence and could also have a noticeable influence on the vase life of cut flowers (Sui et al., 2015). It is also reported that GA_3 has a delaying effect on wilting and is associated with senescence (Eason, 2002). Application of GA_3 also promote branch growth, flower bud development, and improve flower quality (Guan et al., 2019). In another study, it was reported that the application of plant hormones on *Gladiolus* plants, flowering parameters and also vase life were highly influenced (Orpa et al., 2023). GA_3 is also used as a postharvest treatment to increase the vase life of alstroemeria (Yeat et al., 2012). Also, it was shown that salicylic acid at 120 mg/L influenced it a positive way the number of leaves, the number of inflorescences, stem diameter in *Tagetes* (Basit et al., 2018).

Plant hormones are substances naturally created by plants that manage plant functions and development, such as root and plant development and fruit ripening (Mirihagalla & Fernando, 2020; Anfang & Shani, 2021). Moreover, they are significant and vital elements required to regulate plant development throughout the life cycle, from embryogenesis to reproductive development (Sajjad et al., 2017; Toungos, 2018; Mendel et al., 2020).

According to research, the use of growth regulators such as gibberellic acid (GA_3) and benzylaminopurine (BAP) in the cultivation of Lisianthus is limited because there are only a few reports indicating that gibberellins promote budding in rosette plants (Castillo-González et al., 2018). The growth stimulator GIBB A3 is intended for use in a number of agricultural and horticultural crops: vegetables, cereals, sunflowers, potatoes, fruit trees and shrubs, alfalfa and clover, vines. The application of the growth stimulator GIBB A3 determines increases in production, larger and firmer fruits, with good shelf life and quality. The growth stimulator GIBB A3 contains 20% gibberellic acid GA_3 (gibberellin) which is not toxic or dangerous in the doses recommended for use (SemintePlante).

The *Eustoma grandiflorum* (Lisianthus) is a member of the Gentianaceae family and is an herbaceous flowering plant (World Flora Online), it has been cultivated since the 1960s (Ohkawa et al., 1999).

The Croma variety group from within the species was used for the 'Croma lavender' a) variety in the experiment. The thick, strong petals and extra-double flowers characteristic of the Croma variety make it stand out among the premium varieties. Due to the strength of the flowers and stems, it is very suitable for cold chain transportation. Rosette formation may occur in high temperature conditions. Its height varies between 70 and 90 cm (Takki.eu).

Within the Rosita variety group, we have chosen the variety `Rosita yellow' for the experiment. The Rosita cultivar group is characterized by double-flowered inflorescences, thick petals, and strong stems, so it is easy to grow and the flowers are easy to transport. Good and in the vase long-lasting color also delight consumers. Their height is between 75 and 85 cm (Sakataornamentals.com).

Since Lisianthus in recent years had become a very popular plant worldwide and there is an ever-increasing demand for it, we wanted to test whether it can be successfully grown under our climatic conditions (Romania, Brașov). *E. grandiflorum* has an important role in the ornamental market, as it can be found both as a cut or potted flowering ornamental plant. The aim of our research was to determine whether different concentrations of GIBB A3 have a positive or negative effect on the production of cut flowers of the two selected varieties (*E. grandiflorum* `Croma lavender` and *E. grandiflorum* `Rosita yellow`). Our motivation for choosing the GIBB A3 treatment was that, during the past few years, flower production (potted and cut flowers) has reached a significantly higher demand on the market; hence, ornamental plant producers need to increase both the quality and also the cultivated plants. Furthermore, since plant growth regulators have gained higher attention in the previous year's horticulture section, GA_3 is also classified as one of these hormones and can have different positive effects on the cultivated plants; however, the price of GA_3 is quite expensive. Because of this fact, we have tried to use a cheaper version in which the GA_3 percentage is only 20%, still could have a satisfactory influence on the selected plants.

MATERIALS AND METHODS

Experimental Site and Plant Material

The study was conducted in 2022, in Crizbav, Brașov County (45°48'59"N 25°28'27"E) at a commercial greenhouse. The rooted plantlets were obtained from Qualipant SRL, Corunca, Mureș County.

The experimental site was plowed and leveled, and then divided into two large plots: one for *Eustoma grandiflorum* `Croma lavender` (Figure 1a), and the other for *E. grandiflorum* `Rosita yellow` (Figure 1b). Within each of these two large plots, five smaller plots were created for the hormone treatments. After the distribution of the plots was ready, the irrigation system was put in place. Irrigation was done by means of drip tapes. As a defense against weeds, a mulch barrier was added in each row. The plantlets were then planted at a distance of 10 x 15 cm. 40 plants were placed in each small plot, for a total of 400 plants of both varieties. Irrigation was done twice a day, for 10 minutes in the morning and in the evening for 15 minutes.



(a) (b)

Figure 1. The two selected *Eustoma grandiflorum* varieties: `Croma lavender` (a), and `Rosita yellow` (b)

Experimental Design

The treatments were started 8 weeks after planting. The first treatment was made on the 16th July and then repeated every two weeks, so the treatments were made on the following dates: 30th of July, 13th of August, 27th of August, the last one being made on the 10th of September. Treatments were applied as foliar fertilizers using a normal sprayer (the appropriate dose for each plot). In the case of both *Eustoma*'s, the first plot was the control part (C), which was only treated with clean water; the following plots (A1, B1) received 25 mg/L GIBB A3. The hormone dose increased with each plot, so the next 40 plants (A2, B2) received 50 mg/L, the 4 plots (A3, B3) 100 mg/L, and the last one received 150 mg/L (Table 1). During the treatments, a plastic separator was used so that the spray would not transfer to the other treatments (Castillo-González et al., 2018; Kwon & Heo, 2024; Pal, 2019).

Table 1. Experimental processing settings

Treatment	Rosita yellow	Croma lavender
Control (clean water)	CA	CB
25 mg/L GIBB A3	A1	B1
50 mg/L GIBB A3	A2	B2
100 mg/L GIBB A3	A3	B3
150 mg/L GIBB A3	A4	B4

Data Evaluation

The measurements were made every two weeks before spraying. The following data were recorded on the plants: growth (cm), shoot number (pcs), shoot length (cm), stem thickness (mm), diameter of the plant (cm), number of flowers (pcs), flower diameter (cm).

Initially, no differences were observed between the varieties or the different treatments.

Statistical Analysis

The significance of the differences between the treatments was tested by applying a two-way ANOVA at a confidence level of 95%. When the ANOVA null hypothesis was rejected, Tukey's post hoc test was carried out to establish the statistically significant differences at $p < 0.05$ (Hammer et al., 2001).

Heatmaps and dendrograms were created by employing Euclidean distance to indicate the similarities and differences in the development of two Lisianthus varieties using different concentrations of GIBB A3. The packages used included clusterProfiler, dendextend, and ggplot from the R database (version 4.05).

RESULTS AND DISCUSSIONS

Growth

The treatments affected the plants in different ways (Figure 2). On the one hand, when the two Lisianthus varieties were compared, no significant differences were found. On the other hand, the growth of the plants was significantly affected by the GIBB A3 treatments. As the concentration increased, the height of the plants also changed. The control plants were the lowest (`Rosita yellow` - 46.31 cm and `Croma lavender` - 46.23 cm), in contrast, the 150 mg/L

GIBB A3 treatment achieved the highest growth, which was 60.29 cm for `Rosita yellow`, whereas for `Croma lavender` it was 60.45 cm.

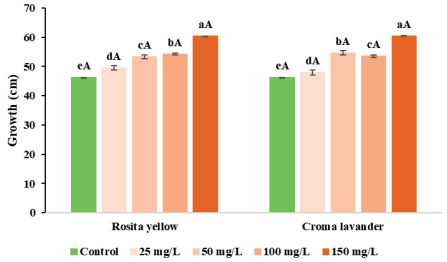

Figure 2. Effect of different concentrations of plant hormones on the growth of selected Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

Stem Thickness

When comparing the Rosita yellow and Croma lavender Lisianthus varieties, it was found that significant differences appeared in stem thickness (Figure 3). According to the data, by increasing the concentration of GIBB A3, the treatments significantly affected the stem thickness compared to the control. The thinnest stems were measured in the control plants (`Rosita yellow` - 7.6 mm and `Croma lavender` - 7.26 mm), followed by the treatments with concentrations of 50, 100 and 150 mg/L. The greatest stem thickness was recorded with the 25 mg/L GIBB A3 treatment, where it was 11.13 mm for `Rosita yellow` and 11.5 mm for `Croma lavender`.

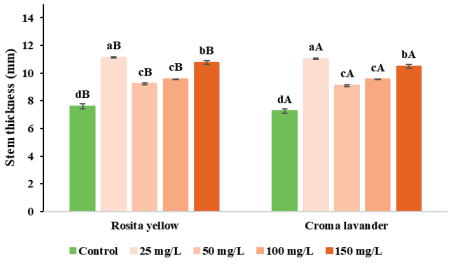

Figure 3. Effect of different concentrations of plant hormones on the stem thickness of selected Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

Plants Diameter

The plant diameter of the `Croma lavender` variety significantly exceeded the `Rosita yellow` variety, except in the case of the 100 mg/L treatment (Figure 4). Furthermore, compared with the control plants, the diameter of the plants increased significantly in parallel with the increase in concentration. It can be deduced from the collected dofa ththose of the control plants at `Rosita yellow` reached 7.98 cm and at Croma lavender` reached 9 cm. The greatest plant diameter was observed in the 150 mg/L GIBB A3 treatment, where it was 25.75 cm for Rosita yellow and 26.73 cm for `Croma lavender`. Interestingly, in the case of the `Croma lavender` variety, no significant differences were found between the control and the 25 mg/L treatment.

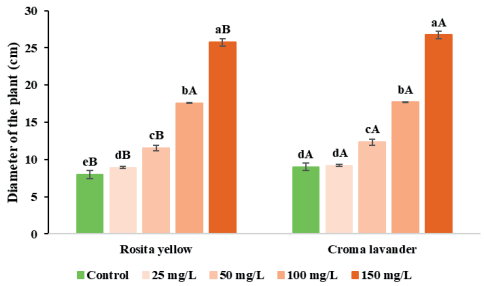

Figure 4. Effect different concentrations of plant hormones on the diameter of plants from the selected of Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

Number of Shoots

Considering the number of shoots, no significant differences were found among the three higher dose treatments (50, 100, and 150 mg/L) when comparing the two varieties (Figure 5). However, in the case of the control and the 25 mg/L treatments, significant differences were recorded when comparing the two selected Lisianthus. The treinments significantly affected the number of shoots at both varieties, with the exception of the 25 mg/L treatment for the `Croma lavender` variety, where no significant difference was found compared with the control.

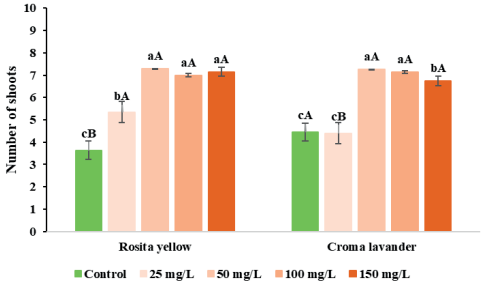

Figure 5. Effect different concentrations of plant hormones on the shoot number of the selected of Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

Length of Shoots

Significant differences were found between the control and the treatments when comparing shoot length in the case of both Lisianthus varieties (Figure 6). The longest shoot length was obtained at the 150 mg/L treatment for the Rosita yellow variety, which was 38.09 cm, and for the Croma lavender variety, it was also observed in the treatment with the longest shoots, where we measured 35.58 cm. When we compared the two varieties, we also determined significant differences, with the exception of 25 and 50 mg/L treatments.

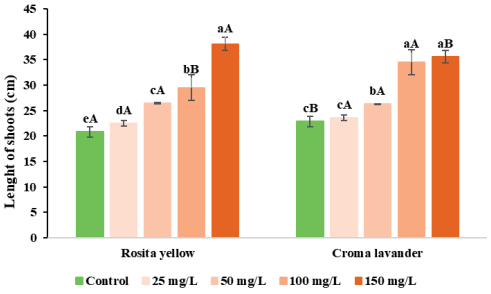

Figure 6. Effect of different concentrations of plant hormones on shoot length of the selected Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

Diameter of Flowers

In the case of flower diameter, a significant increase was found in the 25, 50 and 100 mg/L treatments compared to the control (Figure 7). Interestingly, we found a significant difference between the control and 150 mg/L for Rosita yellow, but not for the other variety (Croma lavender) subjected to the same treatment. In the case of the comparison between the two varieties, no significant differences were found in the 25, 50 and 100 mg/L treatments, in contrast, significant differences were found between the control and 150 mg/L treatments.

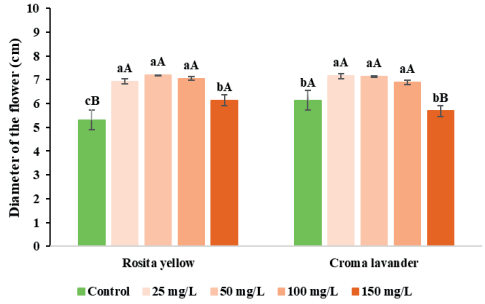

Figure 7. Effect of different concentrations of plant hormones on the flower diameter of the selected Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

Number of flowers

Regarding the number of flowers, the best results were obtained with the 150 mg/L GIBB A3 treatment. At Rosita yellow, a significant difference can be seen between the control plants and the treatments (Figure 8).

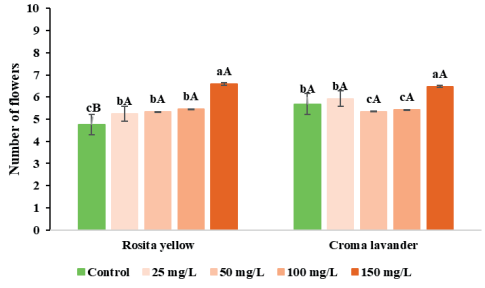

Figure 8. Effect of different concentrations of plant hormones on the number of the selected Lisianthus varieties ('Rosita yellow' and 'Croma lavender'). Bars represent the means ± SE (n = 40). Different lowercase letters indicate a significant difference between treatments, and uppercase letters indicate a significant difference between the two varieties ($p < 0.05$)

For Croma lavender, there is no significant difference between the control and the 25 mg/L treatment, but when comparing the other treatments to the control, a significant difference can be observed. Furthermore, a decrease in the number of flowers was recorded in the Croma lavender treatment at 50 and 100 mg/L. Moreover, a significant difference was reported between the two Lisianthus varieties only in the case of the control.

Hierarchical Clustering and Heatmap Visualization of the Plant Development Characteristics

The distinct cluster positions of the Lisianthus Croma lavender variety made comprehensible the influence on growth and development imposed by the used GIBB A3 concentrations (Figure 9). The primary cluster positioned the highest used concentration (i.e., 150 mg/L) which proved to be clearly distinct compared with the other used solutions, clearly discriminated by growth, plant diameter, and flower number. Although a positive influence in terms of plant and flower development using the 150 mg/L GIBB A3 concentration is obvious, a significant reduction in the number of inflorescences has been observed, which is commonly reported when using these biostimulants. Next, the second cluster divided the groups into two sub-clusters according to the used GIBB A3 solutions. Therefore, both the 50 and 100 mg/L concentrations presented similarities in terms of flower diameter, number of shoots, and growth. As compared to the 150 mg/L concentrations, in this respect the use of lower concentrations led to a higher flower diameter although the number of flowers decreased significantly. The subsequent sub-cluster grouped the control and the lowest GIBB A3 concentration, which imposed the lowest effect on the Lisianthus plants as observed by similarities in plant diameter, but also regarding the shoot length and number. Overall, the results suggest that lower concentrations of GIBB A3 may prove to be more beneficial in terms of promoting flower diameter, while higher concentrations may lead to a decrease in flower number. The control and lowest GIBB A3 concentration group exhibited similar effects on plant growth parameters, indicating minimal impact on plant development.

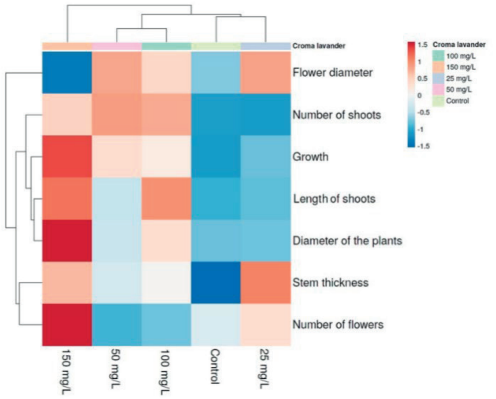

Figure 9. Hierarchical clustering and heatmap visualization of the plant development characteristics in Croma lavender as influenced by different concentrations of growth parameters

Regarding the Rosita yellow Lisianthus variety, the cluster placements made it possible to observe whether the employed GIBB A3 concentrations positively impacted growth and development (Figure 10). The primary cluster revealed the control group, which was clearly anticipated by the plants' slow development, as evidenced by the significantly smaller growth, plant diameter, number of shoots, and flowers. The subsequent group highlighted the 150 mg/L solution, which positively impacted the plants' growth, diameter, but also the length, as shoots and number of flowers, as was also observed in the other variety (i.e., Croma lavender). The following sub-cluster revealed the concentration of 25 mg/L GIBB A3 which showed a positive influence mainly on stem thickness and flower diameter; conversely, a negative effect has been observed in the plants' diameter and shoot length. The last sub-cluster highlighted similarities in terms of flower diameter and number of shoots using both the 50 and 100 mg/L concentrations. Discrepancies in terms of overall growth, plant diameter, and shoot length have been observed with regard to the 100 mg/L solutions. Overall, the results suggest that the concentration of GIBB A3 has a significant impact on certain aspects of plant growth and development in both Rosita yellow and Croma lavender varieties. It is important to further investigate the specific effects of different concentrations of GIBB A3 on various parameters to optimize plant growth and flower production.

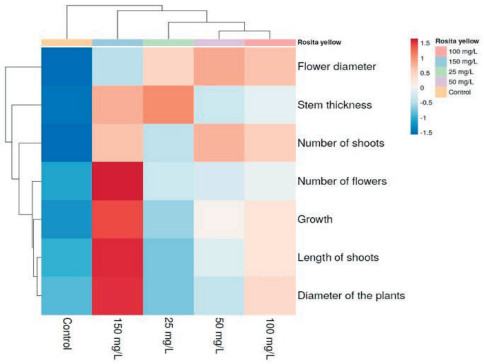

Figure 10. Hierarchical clustering and heatmap visualization of the plant development characteristics in Rosita yellow as influenced by different concentrations of growth parameters.

Plant hormones have an important role in controlling plant development (Davière & Achard, 2013; Claeys et al., 2014) and also in signalling plant responses to abiotic and biotic stresses (Bari & Jones, 2009; Wu et al., 2021). Plants can also produce a diverse variety of hormones, which include gibberellins, auxins, cytokinins, abscisic acid, and salicylic acid (Gomez-Roldan et al., 2008; Umehara et al., 2008). Bari and Jones (2009) mention that gibberellins (GA) promote plant growth by promoting the breakdown of negative regulators of growth called DELLA proteins. According to Hedden and Sponsel (2015) gibberellins are a family of plant growth regulators produced naturally. Gibberellins are also produced by fungi and bacteria, not only by higher plants (MacMillan, 2001). GA also has effects on germination, stem elongation, flowering, seed dormancy, leaf and fruit senescence, and enzyme induction (MacMillan, 2001; Pacifici et al., 2015; Bagale et al., 2022). In 2002 Spielmeyer et al. (2002) report that GA is a key element of the Green Revolution, it is also mentioned that there is a continuously increasing interest in gibberellins research because of their current and possible applications in crop improvement (Castro-Camba et al., 2022). Moreover, Shtin et al., (2022) mention that gibberellins are a key regulator for the root meristem development, and this phytohormone can activate as a molecular clock for the root development.

From our results, it can be concluded that the plant development of both studied varieties was significantly increased by the treatments compared to the control plants. The smallest amount of gibberellin (25 mg/L) used as foliar fertilization already increased the growth of the plants compared to the control. However, the highest significant differences were reported at the biggest amount of gibberellin (150 mg/L) used in the experiment. The stem height is not an important factor in the case of the potted *Eustoma* but, on the contrary, it is highly important for the cut Lisianthus. It is one of the most popular flowers in flower arrangements, it is therefore advisable to have as long a stem as possible for it will last longer in the vase. At the same time, the stems are cut back on a daily basis in order to increase the longevity of the plants, so there is a danger that if the stem remains too short, the plant loses its decorative value (Nagh Shiband Hassani et al., 2020). In previous research it was reported that application of GA_3 and Rhizobium that significantly increased the growth, and also the nutrient content of *Cicer arietinum* L. (Rafique et al., 2021). Moreover, in the case of *Beta vulgaris* L. a proper concentration of 160 mg/L of GA_3 sprayed 60 days after planting is the most recommended to increase growth (Castro-Camba et al., 2022). Moreover, it was also reported that GA_3 can improve the flowering, vase life, and growth of lilium by increasing water uptake (Leilah & Khan, 2021).

Regarding the stem thickness of the subjected Eustoma varieties, in both cases the treatments with GIBB A3 influenced it in a positive way; however, the thickest stem was recorded in plants treated with 25 mg/L. This could be explained by the fact that the other treatment concentrations were too high. In addition, the thickness of the stem is an important factor in the cut flower industry. Regarding the thickness of the stem, it is important that the stem is as thick as possible because otherwise it can break easily. Another aspect regarding stem thickness is important when selling the plant: the thicker the stem of the plant, the higher its market value, because for florists it is important to have a more durable stem, and generally a thicker stem diameter means a longer vase life (Hojatipour & Hassanpour Asil, 2022). In previous research, it was reported that a concentration of 300 ppm of GA_3 foliar application highly enhanced the stem diameter compared to the other treatments

(Poorani et al., 2024). In another study, Lisianthus seeds were treated with GA_3 and it was reported that a concentration of 1000 ppm resulted in the highest mean value of stem thickness (Shah et al., 2018).

Here again, the plant diameter was clearly influenced in a positive way by GIBB A3 treatments; yet, in this case, the highest diameter was determined at 150 mg/L. Furthermore, when comparing the two varieties, the Croma lavender reached a higher diameter than the Rosita yellow.

Under our experimental conditions, the number of shoots reported significantly different results under the effect of the treatments compared to the control in the Rosita yellow variety. On the other hand, in the Croma lavender variety, no difference was observed under the 25 mg/L treatment compared to the control, however, in the case of the 50, 100, and 150 mg/L GIBB A3 treatments, the number of shoots increased compared to the control. In an earlier study, it was reported that the highest number of side shoots and number of leaves per plant were determined at double pinching and 150 ppm of GA_3 (Lakshmaiah et al., 2019).

Considering the length of shoots, it can be clearly observed that the higher the concentration of the treatment is, the higher the length of the shoots. At *Eustoma grandiflorum* Rosita yellow, the greatest shoot length was reported at 150 mg/L GIBB A3 treatment. On the other hand, at *E. grandiflorum* Croma lavender variety, the 100 and 150 mg/L GIBB A3 treatments reported the highest significant differences.

From our results, it can be concluded that, on the one hand, the application of GIBB A3 increased the diameter of the flowers; however, the highest concentration (150 mg/L) reported smaller diameters compared to the other treatments. On the other hand, when comparing the number of flowers of both *Eustoma grandiflorum* varieties, the 150 mg/L GIBB A3 treatment reported the highest number. Interestingly in the case of the Croma lavender variety, an inhibition of flower number was observed under the influence of 50 and 100 mg/L of GIBB A3. In a study, it was reported that 10 and 50 mg-1 of GA_3 increased the flower diameter of Asiatic lily (Othman et al., 2021). In another experiment, the authors determined that gibberellin treatment caused a large number of flowers; unfortunately, with wilting and senescence symptoms (Calaboni et al., 2023) which reduces the post-harvest quality of Lisianthus. Furthermore, it was also reported that in the case of the Gladiolus *hybridus* `Black velvet` cultivar, the number of developing flowers was affected only by a concentration of 100 mg/dm^3 in the second year of the research (Janowska et al., 2018). Other authors reported, in the case of *Tagetes erecta,* that the maximum number of flowers per plant was obtained at a concentration of 250 ppm. Moreover, 300 ppm of gibberellin acid resulted in a longer duration of flowering, up to 58 days (Acharya et al., 2021). At *Chrysanthemum* cv. Thai Chen Queen, was determined that a higher concentration of GA_3 (400 mg/L) increased the vegetative and reproductive growth of the selected plants (Aparna et al., 2018). In the floriculture section is used different plant growth regulators to enhance the production of quality flowers. Additionally, growth regulators facilitate responses to both biotic and abiotic stresses (Chandel et al., 2023). Gibberellin could be one of these beneficial products, which positively promotes flowering and accelerates the flowering process (Pradeepkumar et al., 2020; Panwar et al., 2022). However, it could also have a negative effect on ornamental plants because of the elongation of the internodes (Al-Rawi, 2021), and thus the treated plants could be classified as lower quality.

CONCLUSIONS

During the experiment, the plants fertilized with clean water (control) were the least developed. The tallest plants were obtained at the GIBB A3 concentration of 150 mg/L.

In the case of stem thickness, the best results were obtained with 25 mg/L GIBB A3. Regarding plant diameter, the best data were obtained with the 150 mg/L GIBB A3 treatment. In terms of shoot length, 150 mg/L also reported the best results. From the point of view of the flowers, the flowering of the two varieties did not occur at the same time: the Rosita yellow bloomed earlier, while the Croma lavender variety began to bloom 3 weeks later. According to the observations, the diameters of the flower branches of Rosita yellow were smaller because it has smaller types of inflorescences than

Croma lavender, but their lifespan was much longer. In the case of flower diameter, the best results were measured for the 25, 50 and 100 mg/L treatments, and for the number of flowers for the 150 mg/L treatment.

According to the data from the present experiment, in most cases the best results were achieved at the treatment with a concentration of 150 mg/L. In our opinion, it is even worth trying a higher concentration treatment in the near future.

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