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Assessing the Effect of Plant Growth Stimulants and Retardants on Cyclamen "Halios F1 Salmon Rose" Cultivar

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Abstract: In Eastern Europe, the traditional marketing of cyclamen is in the period from the middle of February to the middle of March. The poor light of winter months and the higher number of plants (because of the reduction in heating costs) often result in elongated plants. To avoid this, it is recommended to use plant growth retardants. At the same time, another problem is that flowers do not rise from the level of rosette due to the unfavorable cultivation conditions. This can be solved with growth stimulants. In the experiment, we tested the effect of growth regulators on the growth of a frequently used variety of cyclamen. We used daminozide and paclobutrazol plant growth retardants for height control and gibberellic acid (GA) and benzyladenine (BAP) as growth promoters for increasing the number of flowers and the length of stems. The results show that daminozide and paclobutrazol are both effective for height control in cyclamen production.

Keywords: cyclamen; cytokinin; daminozide; gibberellic acid; paclobutrazol

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Citation: Bálint, J.; Benedek, K.; Csorba, A.B. Assessing the Effect of Plant Growth Stimulants and Retardants on Cyclamen "Halios F1 Salmon Rose" Cultivar. *Horticulturae* **2024**, *10*, 53. https://doi.org/10.3390/horticulturae10010053

Academic Editors: Margherita Beruto, Emmy Dhooghe and Bruce Dunn

Received: 12 December 2023
Revised: 28 December 2023
Accepted: 29 December 2023
Published: 5 January 2024

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1. Introduction

The cultivation of ornamental plants, in addition to the cultivation of potted ornamental plants, is gaining more and more use worldwide [1,2]. Cyclamens are cultivated in many regions around Europe and are currently considered one of the most popular potted ornamental plants, even though their production can be very expensive due to heating requirements, especially in Middle and Eastern European countries [3,4]. Annually, nearly 200 million plants are produced and sold worldwide, out of which 140–150 million are grown in Europe [5].

On the other hand, some cyclamen species, like *C. purpurascens* or *C. coum var. coum*, are used as medicinal plants [6–8]. *C. persicum* is traditionally propagated by seeds at high costs despite its lack of homogeneity of cultivars [5,9,10]. The cyclamens taxonomically belong to the family *Primulaceaae* and the genus *Cyclamen* with about 21 species [11,12]. It is native to Cyprus, Turkey, Crete, Libya, and Syria [13,14]. The ornamental value is given by its flowers, and the colors range from white to red, pink, and purple, and these flowers usually appear between December and early May [15,16]. In Western European countries, the cyclamen plants are most likely sold in the Christmas period before New Year's Eve [17,18]. The cultivation conditions are favorable for the plants in the period from June to November and, in general, the usage of growth regulators is not necessary. In Romania, the traditional marketing of cyclamen is in the period from the middle of February to International Women's Day in March [18]. In this region, the poor light of winter months and the higher number of plants (because of the reduction in heating costs) often result in elongated plants. To avoid this situation, it is recommended to use plant growth retardants. At the same time, another problem is that the flowers do not rise from the level of rosette due to the unfavorable cultivation conditions. A solution for this problem can be the usage of growth regulators. The role of plant growth retardants and regulators has increased

since the spread of flowering timing and the influence of stem elongation [19]. This can be critical to a successful cultivation because of the market demands [19,20].

Plant growth regulators (PGRs) are defined as natural or synthetic compounds that affect the developmental and metabolic processes in plants [21]. These compounds influence the yield, the number, and quality of flowers, and they are widely used in ornamental plant production [22]. A high number of growth regulators are used to adjust the size of the plants, and it can help if an excessive amount of growth retardants are applied [23].

Cytokinins promote cell division, and these phytohormones play an important role in regulating plant growth and differentiation [24,25]. They also play a crucial role in the regulation of plant responses to environmental stresses such as drought and salinity. Moreover, cytokinins have been identified as key players in the intricate network of plant stress responses. They exhibit a remarkable ability to modulate and mediate plant reactions to various stress conditions, including challenging situations such as drought, salinity, and pathogen attacks. Cytokinins contribute to the maintenance of cellular viability and play a pivotal role in enhancing stress tolerance in plants. These hormones actively engage in activating defense mechanisms, enabling plants to effectively combat and mitigate the detrimental effects of stressors. Through their multifaceted actions, cytokinins serve as critical components in the intricate machinery that orchestrates plant responses to stress [26].

6-Benzylaminopurine (BAP) was the first synthetic cytokinin used in potted plant production, and previous research has shown that the application of BAP successfully delayed senescence in plants [27]. Gibberellins are primarily involved in promoting seed germination and flowering. They also regulate various developmental processes such as leaf expansion, fruit development, and the transition from vegetative to reproductive growth [28]. The effects of gibberellic acid (GA3) have been proven and documented in numerous crops and ornamental plants, as well as cyclamens, as they have the remarkable ability to significantly improve stem elongation and early flowering [29,30]. Gibberellins are also involved in regulating plant responses to environmental cues such as light and temperature [30].

Another way to control the development of potted ornamental plants is to use plant growth retardants. Within the realm of potted cyclamen production, the utilization of growth retardants to regulate plant height is deemed to have limited practicality; however, the literature on this subject matter is rather scarce with only a few papers documenting such findings [31]. Most of the plant growth retardants inhibit the biosynthesis of gibberellin (GA), which is the hormone that is responsible for plant growth [32,33]. It is already known that GA metabolism is sensitive to irradiance, and in Eastern European countries, the low irradiance increases GA biosynthesis [34], which results in shoot elongation, and this effect has been demonstrated for a large number of plant species in previous research [35]. A popular plant growth retardant used by ornamental plant growers is daminozide. This chemical compound reduces the plant cell size, shortens the length of the stem, and inhibits the growth of the apical meristem [36]. Paclobutrazol is another effective and widely used growth retardant, which shortens the length of stems but can also reduce the size of bracts in the case of excessive use in ornamental plants [37]. The effect of this retardant can be described by a compact growth plant, which also accelerates the inflorescence and reduces the height of the potted ornamental plants [38].

Our aim was to investigate and evaluate the effects of plant growth regulators and retardants used in Romania in potted *Cyclamen persicum* cultivation. In addition, another aim was to develop a cultivation technology that results in compact, healthy, and attractive plants to fulfill consumer expectations and meet market demands.

2. Materials and Methods

The experiment was performed in a greenhouse with a double-inflated foil cover in Miercurea Nirajului, Romania. The tables were 2 m wide and 22 m long on which the potted cyclamens were grown, and the irrigation was constant during the experiment under con-

trolled humidity and temperature. In summer, the average temperature was 20 °C, while in autumn/winter, it was 15 °C (80% relative humidity average, and 17–18 °C temperature average under the whole experiment) (Figure 1). The humidity and temperature were measured with a data logger (LASCAR EL-USB-2), and the heating was operated by a central heating system.

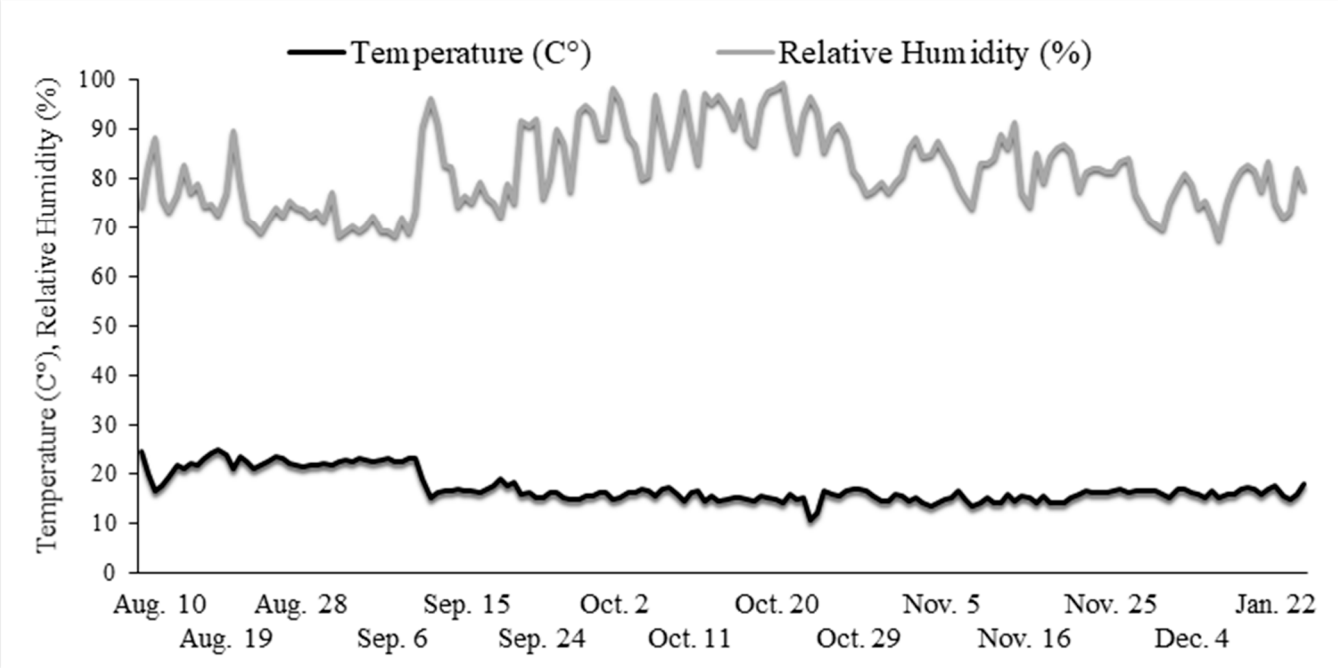

Figure 1. Temperature (°C) and relative humidity (%) during the experiment.

The cyclamen cultivar Halios F1 Salmon Rose with pink flowers was used in the experiment. The morphological description of the "Halios F1 Salmon Rose" is the following: large flowers suitable for 13–20 cm pots, flowering from October to March, good shelf life and a sturdy plant habit, tolerant of high temperatures.

The plant material was bought from S.A.S. Morel Diffusion, France. The cyclamens were grown in propagation trays (Xtray 128), and we planted them into pots with a 12 cm diameter (700 cm^3 volume) on 10 August, in five rows, each row containing six plants in four replications. The first row from each replication did not receive any treatment; they were kept as a control (plants were sprayed only with clean water) (Table 1).

Table 1. Different treatments used in the experiment.

Experimental Variants	Commercial Name	Active Ingredient (According to Label)	Dosage	Observations
T1 (control)	-	-	-	-
T2	Bonzi (Syngenta, Ontario, USA)	paclobutrazol (PBZ)	30 mg/L PBZ	used two times
T3	Alar 85 (Arysta LifeScience, Tokyo, Japan)	daminozide (DAM)	2500 mg/L DAM	used two times
T4	Florgib (Fine Americas, California, USA)	gibberellic acid (GA)	20 mg/L GA3	used two times
T5	Fascination (Nufarm, Illinois, USA)	gibberellins A_4A_7 + 6-benzylaminopurine (GA4+7 + BAP)	10 mg/L GA4+7 + 10 mg/L BAP	used two times

A total of 120 plants were used in the experiment. The substrate used for pots was a combination of peat and perlite with 75% and 25% proportions. On 5 October, the cyclamen cultivars were sprayed for the first time with the selected plant growth regulators and retardants. The second treatment was made on 28 October 2016, and the first cyclamens with full bloom were obtained in early January 2017 (Figure 2). The time of the treatments was selected based on our applied technological experience. During the experiment, five measurements on 120 potted cyclamens were performed at four different treatments. The measured plant characteristics during the experiment were the following: rosette diameter, rosette height, peduncle height, peduncle diameter, plant height, number of flower buds, number of flowers, and inflorescence diameter. In the case of rosette, peduncle, and inflorescence diameter and height, we used a tape measure and a digital caliper. The first measurement took place on 15 November, and the following measurements were on 30 November, 14 December, 4 January, and 22 January (Table 2). The first cyclamens in full bloom appeared in early January.

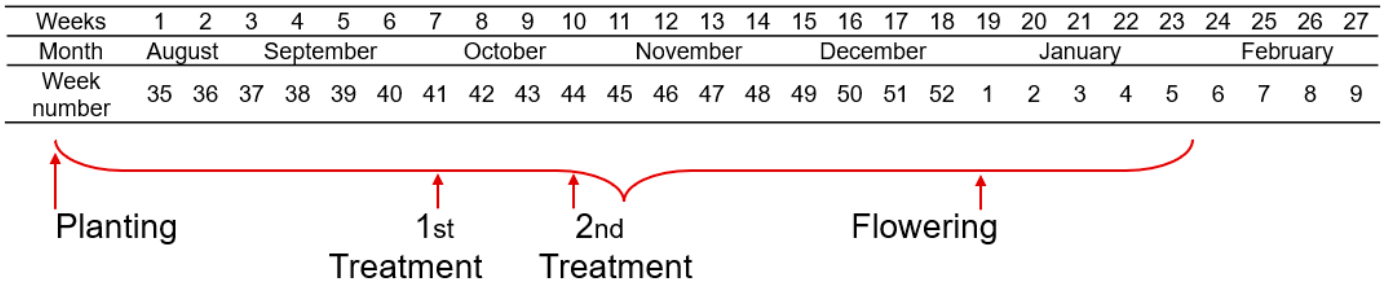

Figure 2. Date of actions during the experiment in chronological order.

Data Analyses

The distribution of the data was examined with the Kolmogorov–Smirnov test. The original data were not distributed normally; therefore, the nonparametric Kruskal–Wallis was used, and afterwards, Mann–Whitney U tests were used to compare the treatments. Means with different letters on figures represent statistically significant differences.

Table 2. Date and time with the measured characteristics.

	15 November				**30 November**						**14 December**						**4 January**					
	Rosette Diameter		**Rosette Height**		**Rosette Diameter**		**Rosette Height**		**Number of Buds**		**Rosette Diameter**		**Rosette Height**		**Number of Buds**		**Rosette Diameter**		**Rosette Height**		**Number of Buds**		**Number of Flowers**	
	Mean	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***	***Mean***	***a***
Control	19.48	*b*	8.27	*a*	21.33	*a*	8.58	*bc*	0.42	*ab*	22.77	*ab*	8.79	*b*	1.71	*b*	22.90	*b*	8.96	*c*	11.08	*b*	3.92	*ab*
DAM	19.68	*b*	8.16	*a*	21.25	*a*	8.42	*c*	0.58	*a*	22.38	*bc*	8.83	*b*	1.70	*bc*	22.79	*b*	9.38	*b*	8.58	*c*	3.25	*bc*
PBZ	19.98	*ab*	8.13	*a*	20.71	*b*	8.25	*c*	0.04	*c*	22.10	*c*	8.81	*b*	0.79	*c*	22.90	*c*	9.19	*bc*	7.08	*c*	2.29	*c*
GA4+7 + BAP	19.63	*b*	8.35	*a*	21.60	*a*	9.25	*a*	0.29	*abc*	23.02	*a*	9.48	*a*	2.83	*a*	23.74	*a*	10.33	*a*	23.09	*a*	5.13	*a*
GA3	20.46	*a*	8.18	*a*	20.54	*b*	8.92	*b*	0.25	*bc*	21.02	*d*	8.90	*b*	2.67	*ab*	21.71	*d*	9.08	*bc*	25.22	*a*	5.13	*a*

Significance: Means with different letters are significantly different from each other according to the applied statistical test ($p \leq 0.05$, Mann–Whitney U test).

3. Results

3.1. Rosette Diameter under the Effect of PGRs and Plant Growth Regulators

According to our results, the growth retardants and regulators influenced the rosette diameter significantly. The smallest diameter was obtained in cyclamens sprayed with paclobutrazol (PBZ), which significantly differed from the control treatment and from the plants treated with growth regulators (GA3, GA3 + BAP). Conversely, no noteworthy variation was observed between the control treatment and the plants that were sprayed with a combination of growth regulators (GA4+7 + BAP). (Figure 3).

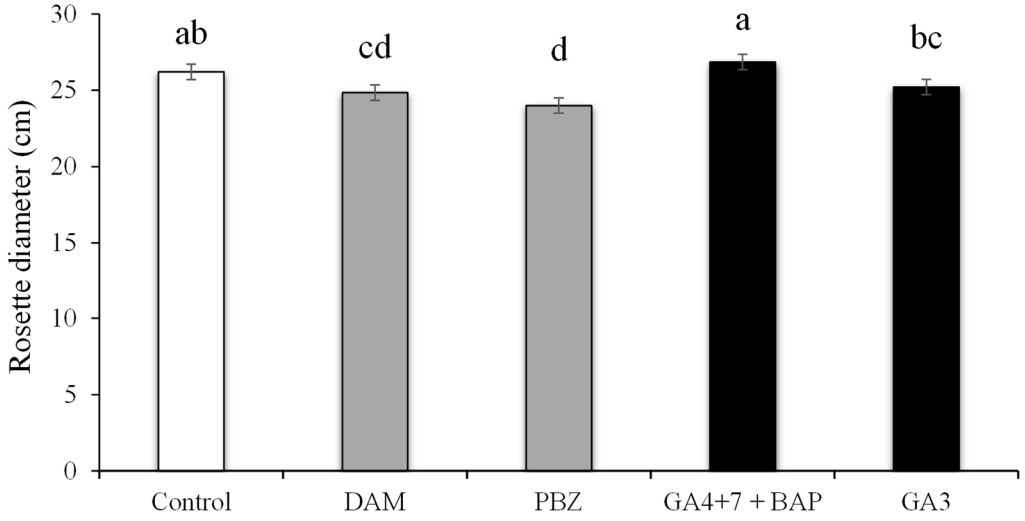

Figure 3. Rosette diameter under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.2. Rosette Height Influenced by PGRs and Plant Growth Regulators

Retardant treatments significantly reduced the height of the rosettes of potted cyclamens. The plants sprayed with paclobutrazol (PBZ) and daminozide (DAM) produced smaller rosettes than plants under plant growth regulator treatments (GA3, GA4+7 + BAP). However, it is worth noting that there was no significant disparity observed between the control treatment and the plants treated with plant growth regulators (Figure 4).

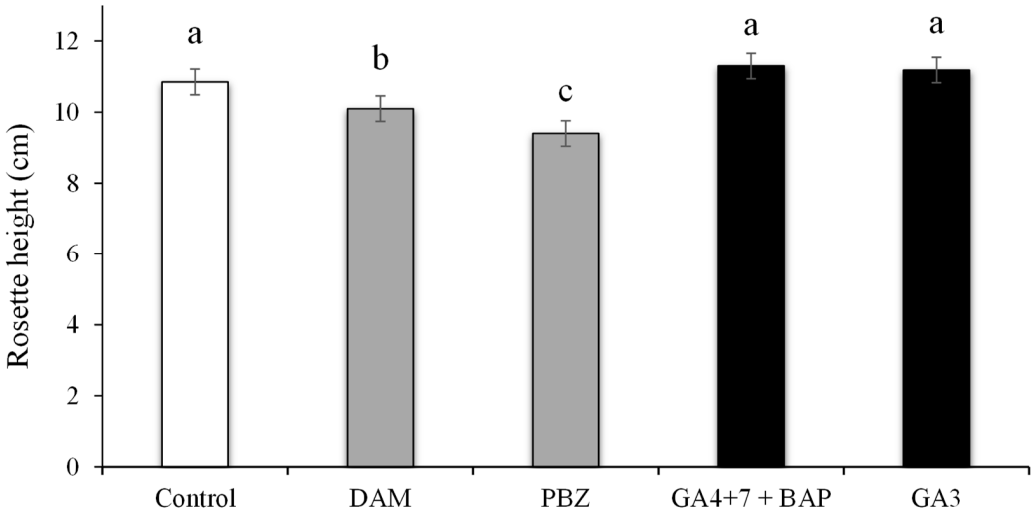

Figure 4. Rosette height under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.3. Peduncle Height under the Effect of PGRs and Plant Growth Regulators

The length (height) of the peduncles was profoundly impacted by the application of both plant growth retardants and plant growth regulators. Notably, there were significant enhancements observed in the peduncle length of the plants treated with plant growth regulators (GA3) when compared to the control treatment. Additionally, substantial disparities were found between the cyclamens subjected to plant growth regulators (GA3, GA4+7 + BAP) and those treated with plant growth retardants (PBZ, DAM). It is worth highlighting that the shortest peduncle length was recorded in the plants treated with paclobutrazol (PBZ). (Figure 5).

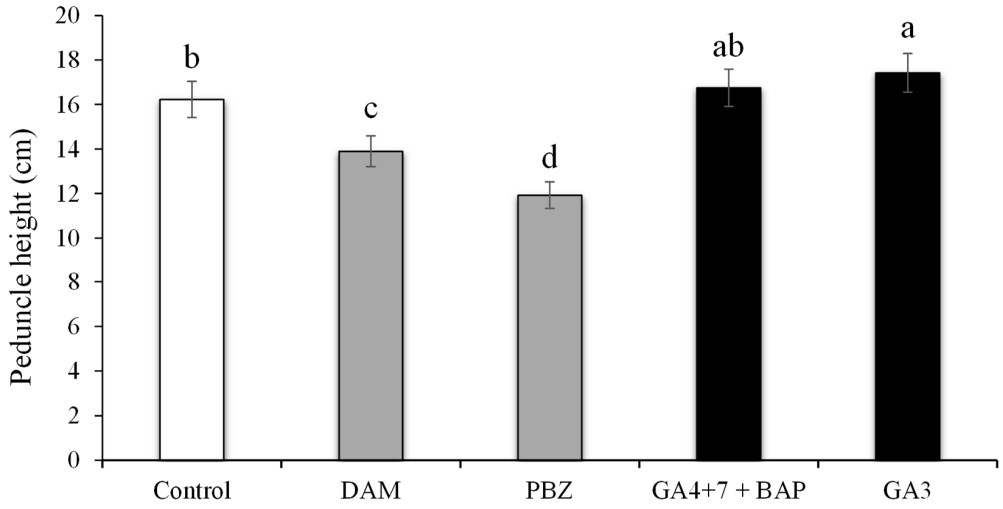

Figure 5. Peduncle height under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.4. Peduncle Diameter Influenced by PGR's and Plant Growth Regulator

Based on our findings, it is evident that the application of growth regulators and growth retardants had a significant impact on the diameter of peduncles in cyclamen plants. Specifically, the cyclamen cultivars that were treated with paclobutrazol (PBZ) and daminozide (DAM) exhibited thicker peduncles compared to the plants treated with plant growth regulators (GA3, GA4+7 + BAP) or the control treatment of water (Figure 6).

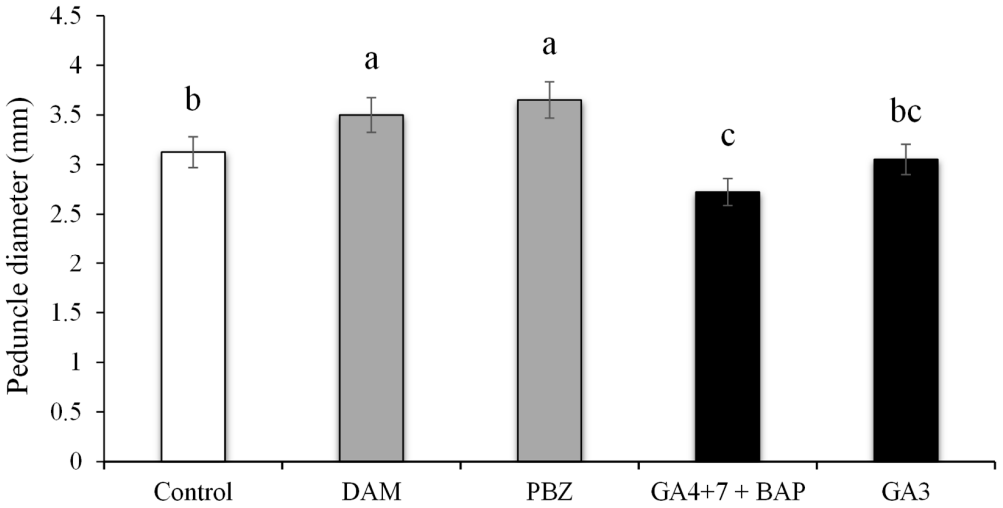

Figure 6. Peduncle diameter under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.5. Plant Height under the Effect of PGRs and Plant Growth Regulators

The plant heights were substantially affected by the application of both plant growth retardants and plant growth regulators. Notably, the plants treated with paclobutrazol (PBZ) and daminozide (DAM) were considerably shorter compared to the plants treated with plant growth regulators (GA3, GA4+7 + BAP). The tallest plants were observed after the treatment with plant growth regulators, and this difference was statistically significant when compared to all other treatments (Figure 7).

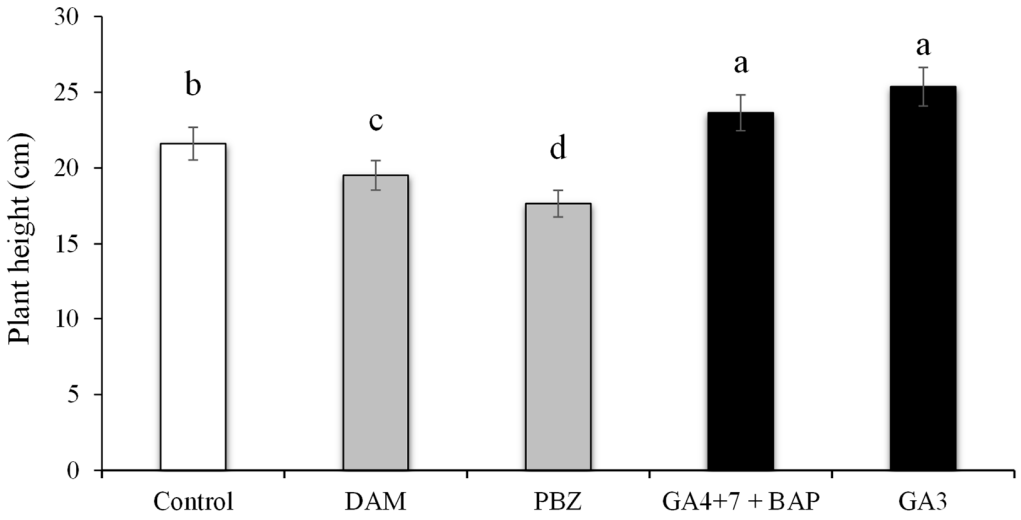

Figure 7. Plant height under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.6. Number of Flower Buds Influenced by PGRs and Plant Growth Regulators

The number of flower buds was significantly higher on cyclamen cultivars treated with plant growth regulators (GA3, GA4+7 + BAP) compared to the cultivars treated with plant growth retardants (DAM, PBZ) or to control treatment. In addition, a higher number of flower buds were recorded in the control group compared to the cyclamens treated with PBZ (Figure 8).

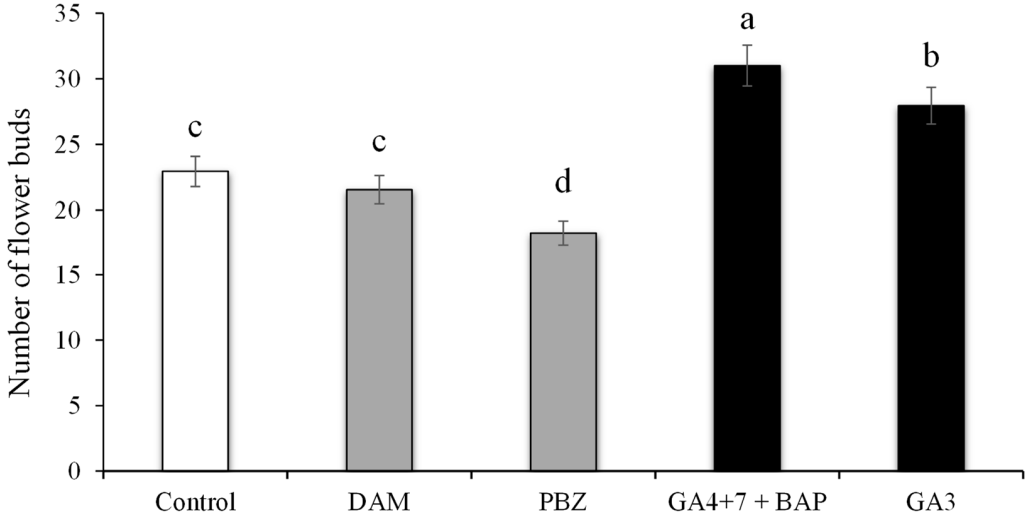

Figure 8. Number of flower buds under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.7. Number of Flowers under the Effect of PGRs and Plant Growth Regulators

According to our results, the plant growth regulators and growth retardants significantly influenced the number of flowers in cyclamen cultivars. The best results were obtained after the treatments with plant growth regulators (GA3, GA4+7 + BAP), which significantly differed from all treatments. The weakest result in the number of flowers was obtained after the PBZ treatment, which was significantly different from the control group, too (Figure 9).

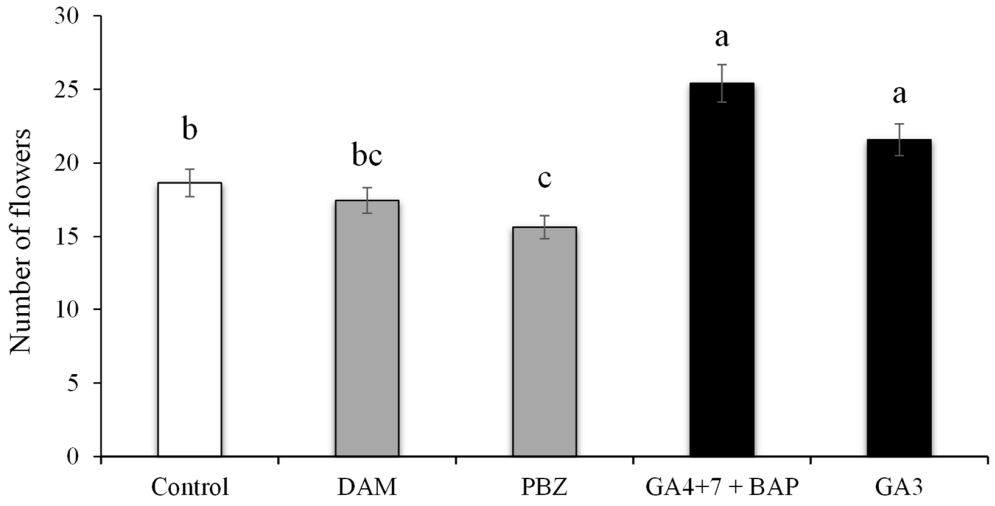

Figure 9. Number of flowers under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

3.8. Inflorescence Diameter Influenced by PGRs and Plant Growth Regulators

The inflorescence diameters were influenced after the plant growth regulator and plant growth retardant treatments. Significantly higher inflorescence diameters were found between the GA3, GA4+7 + BAP-treated cyclamen cultivars compared to plants treated with plant growth retardants (DAM, PBZ) and control. No significant differences were obtained between the control and plants treated with DAM or PBZ regarding inflorescence diameter (Figure 10). At the end of the experiment, the differences between the different treatments were clearly visible (Figure 11).

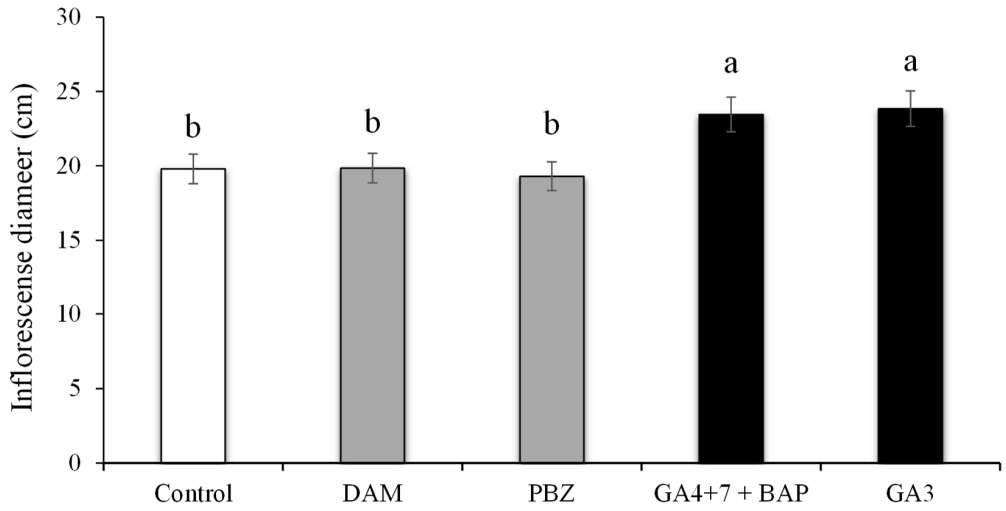

Figure 10. Inflorescence diameter under different plant growth retardant and plant growth regulator treatments in *C. persicum* "Halios F1 Salmone Rose" variety (Mann–Whitney test $p < 0.05$). Different letters mean statistically significant differences.

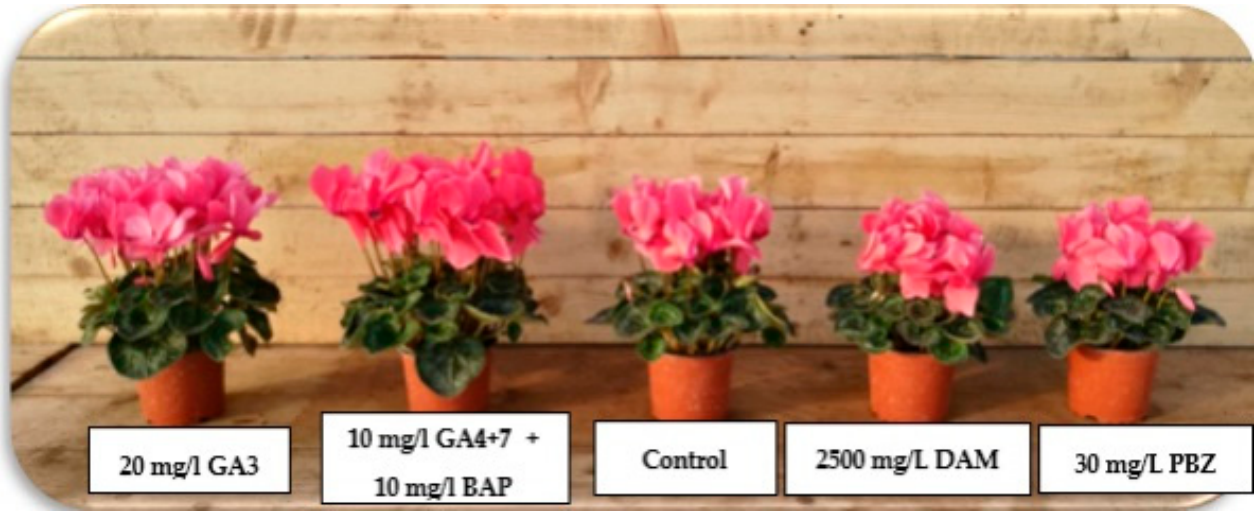

Figure 11. Differently treated plants at the end of the experiment.

4. Discussion

In our experiment, we have demonstrated that the proper use of plant growth regulators can favorably influence the growth, flower, and quality parameters of the selected cyclamen cultivar, and these plants can also fulfill the customer demands. In a two-year experiment in Jordan, it was found that treatments with GA3 and gibberellic acid A4+A7 significantly hastened the flower development and increased the peduncle height [29]. The treatment with 6-benzylaminopurine (BAP) was ineffective regarding peduncle length [29]. Our results are in agreement with the results obtained in the experiment. However, in the case of peduncle length, we observed the opposite because cyclamens treated with BAP provided one of the best results for us. In contrast, in the case of peduncle diameter, GA3 and the combination of BAP and GA4+7 treatment provided the lowest results.

Plants treated with GA3 exhibited higher plant height, leaf area and root length in a research study performed in Romania with different cyclamen cultivars [39]. Research investigations have revealed that the application of exogenous gibberellic acids (Gas), as well as the utilization of GA biosynthesis inhibitors, have demonstrated an impact on the elongation of petioles. According to previous reports by Oh et al. [40], it was observed that *Cyclamen persium* cv. 'Metis Scarlet Red' plants exhibited leaf expansion and petiole elongation when subjected to short-day conditions. These findings suggest that endogenous GA3 and GA4 may play a significant role in the process of petiole elongation in *C. persicum* Mill [39]. In another experiment, it was demonstrated that plant growth retardants inhibit chrysanthemum growth in a significant way but had a negative effect on inflorescence in *Chrysanthemum indicum* and other ornamental plants [41,42]. GA3 has been extensively studied in cyclamen cultivation, and alongside its positive effects, there can also be negative effects from incorrect usage. However, recently, the combined use of GA4+7 + BAP growth stimulants is being applied more frequently in various ornamental plants, which can help promote flowering and reduce negative effects when used in appropriate doses. In Eastern European countries, a unique situation and tradition have developed where the sale of cyclamen peaks on Valentine's Day (February 14) and International Women's Day (March 8). As a result, a significant portion of cultivation falls in the winter months. One prerequisite for successful cultivation is raising the tuberous rosette utilizing the warmth of autumn, which then necessitates the use of growth regulators during the winter months to prevent the excessive elongation of the plants.

Another solution is to provide higher heating during winter while attempting to achieve denser spacing to reduce heating costs per plant. In such cases, the application of plant regulators and retardants may be necessary to counteract elongation. However, after winter cultivation, if the plants cannot be adequately raised under suitable conditions, there may be a need to stimulate flowering to produce high-quality and marketable plants.

In their research, Osterc et al. [43] discovered that *Cyclamen* rosettes of plants exposed to long-day conditions were found to be larger in size compared to those exposed to short-day conditions. Due to this cultivation characteristic, *Botrytis cinerea* also poses a major problem [44]. In the mentioned research, Csorba et al. (2023) [44] used the same Halios F1 Salmon Rose cultivar. Plant hormones like cytokinin and auxin treatments are increasing the resistance against the *Botrytis cinerea* infection, and this effect of the resistance is based on delaying senescence [45]. Bosch et al. 2016 [46] demonstrated that a high concentration of PBZ application can reduce the plant height to a desired level. Similar results were obtained in two different studies: containerized *A. graminifolia* [47] and *R. tingitana* [48]. Our results are in agreement with the published research.

Irradiance is an important factor in the development of *Cyclamen* cultivars. Ravnjak et al. (2019) [49] found that cyclamen species are capable of surviving in forests because of the increased anthocyanin content, which protects them against solar radiation. Furthermore, it was demonstrated in another research study that cyclamen rosettes of long-day exposed plants are higher compared to their short-day exposed peers [43]. Growth retardants can increase the number of flowers, but they also can reduce it or have no influence on them. Alshakhaly and Qrunfleh 2019 [29] showed in their studies that GA3 increased the number of flowers and peduncle length on five different *C. persicum* hybrids. In a similar research study from Poland, the authors demonstrated that spraying the leaves with GA3 at a lower concentration not only initiates the growth of flower stalks but also significantly accelerates flowering and increases the number of flowers [50]. These results are in agreement with our results. In the case of the flower buds and the number of flowers, the best results were obtained after the treatments with plant growth regulators (GA3, GA4+7 + BAP) in our experiment.

In *Chrisanthemum* cultivars, these plant growth regulators had the same positive effect on flowering time and flower size [51]. Malik et al. (2017) [52] described that in each concentration used, plant growth regulators increased the flower number per plant in *Dahlia* variabilis. In another research study with tomato plants (*Lycopersicon esculentum*), a couple of parameters were measured and described under different plant growth regulator treatments. The highest number of flower clusters per plant and the highest number of flowers were recorded after GA3 treatment [53].

The treatments with plant growth retardants negatively influenced the rosette diameter and height in the selected cyclamen cultivar. In the case of PBZ treatment, we measured the lowest values. Another research study conducted with *Reichardia tingitana* showed that none of the PBZ doses altered the inflorescence diameter [48]. In contrast, we measured the lowest inflorescence diameter in control and PBZ-treated cyclamens.

5. Conclusions

Our study provides experimental data on the *C. persicum* "Halios F1 Salmone Rose" variety and the effect of plant growth regulators and plant growth retardants on the measured parameters mentioned above.

Long-term experiments are highly important in ornamental horticulture as well as in other industries. By observing and analyzing the growth, development, and reactions of plants over an extended period of time under various conditions, researchers and growers can gain a better understanding of their needs, optimal conditions, and best cultivation methods. Similar experiments provide opportunities for the development of new varieties, the formulation of nutrient and water management strategies, and the improvement of plants' stress tolerance. As a result, they contribute to the development of more efficient and sustainable practices in ornamental horticulture.

The use of plant growth stimulants and retardants can bring several advantages in the case of cyclamen cultivation. They allow for control of plant size and shape. This is particularly important for products where uniform size and shape are important for marketability. Growth regulators enable plants to become more compact, making them easier to handle and shape. By using growth stimulants and retardants, growers are able

to harvest the crop in a timely and efficient manner. According to our results, active ingredients have delaying effects on flowering, and they slightly reduce the number of flower buds and flowers. We also found a positive effect of these products on the flowering time and number of flowers.

Our results and findings can help the cyclamen growers plan the most appropriate time to intervene and use the plant growth regulators and retardants, especially in Eastern Europe, in order to achieve the best ornamental quality.

To conclude, PGRs have a positive impact on product quality and contribute to the adoption of economical and sustainable cultivation practices.

Author Contributions: Conceptualization, J.B., K.B. and A.B.C.; methodology, J.B. and A.B.C., formal analysis, A.B.C.; investigation, J.B. and A.B.C.; resources, J.B.; writing—original draft preparation, A.B.C.; writing—review and editing; J.B., K.B. and A.B.C.; visualization, J.B. and A.B.C.; All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data associated with the current study are presented in the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Turiné Farkas, Z.; Palkovics, A.; Jóljárt, F. Analysis of Growing *Cyclamen persicum*. *Gradus* **2020**, *7*, 43–49. [CrossRef]
2. Van Huylenbroeck, J. Status of Floriculture in Europe. In *Protocols for In Vitro Propagation of Ornamental Plants*; Jain, S.M., Ochatt, S.J., Eds.; Methods in Molecular Biology; Humana Press: Totowa, NJ, USA, 2010; Volume 589, pp. 365–376. ISBN 978-1-60327-390-9.
3. Darras, A.I. Implementation of Sustainable Practices to Ornamental Plant Cultivation Worldwide: A Critical Review. *Agronomy* **2020**, *10*, 1570. [CrossRef]
4. Karlsson, M.; Werner, J. Temperature Affects Leaf Unfolding Rate and Flowering of *Cyclamen*. *HortScience* **2001**, *36*, 292–294. [CrossRef]
5. Winkelmann, T. Clonal Propagation of *Cyclamen persicum* via Momatic Embryogenesis. In *Protocols for In Vitro Propagation of Ornamental Plants*; Jain, S.M., Ochatt, S.J., Eds.; Methods in Molecular Biology; Humana Press: Totowa, NJ, USA, 2010; Volume 589, pp. 281–290. ISBN 978-1-60327-390-9.
6. Seyring, M.; Ewald, A.; Mueller, A.; Haensch, K.-T. Screening for Propagation Suitability in Vitro of Different *Cyclamen* Species. *Electron. J. Biotechnol.* **2009**, *12*, 1–11. [CrossRef]
7. Foubert, K.; Theunis, M.; Apers, S.; Vlietinck, A.; Pieters, L. Chemistry, Distribution and Biological Activities of 13,28-Epoxy-Oleanane Saponins from the Plant Families Myrsinaceae and Primulaceae. *Curr. Org. Chem.* **2008**, *12*, 629–642. [CrossRef]
8. Quave, C.L.; Plano, L.R.W.; Pantuso, T.; Bennett, B.C. Effects of Extracts from Italian Medicinal Plants on Planktonic Growth, Biofilm Formation and Adherence of Methicillin-Resistant *Staphylococcus aureus*. *J. Ethnopharmacol.* **2008**, *118*, 418–428. [CrossRef]
9. Rode, C.; Gallien, S.; Heintz, D.; Van Dorsselaer, A.; Braun, H.-P.; Winkelmann, T. Enolases: Storage Compounds in Seeds? Evidence from a Proteomic Comparison of Zygotic and Somatic Embryos of *Cyclamen persicum* Mill. *Plant Mol. Biol.* **2011**, *75*, 305–319. [CrossRef]
10. Takamura, T. Cyclamen. In *Flower Breeding and Genetics*; Anderson, N.O., Ed.; Springer: Dordrecht, The Netherlands, 2006; pp. 459–478. ISBN 978-1-4020-4427-4.
11. Compton, J.A.; Clennett, J.C.B.; Culham, A. Nomenclature in the Dock. Overclassification Leads to Instability: A Case Study in the Horticulturally Important Genus *Cyclamen* (Myrsinaceae). *Bot. J. Linn. Soc.* **2004**, *146*, 339–349. [CrossRef]
12. Yesson, C.; Culham, A. A Phyloclimatic Study of *Cyclamen*. *BMC Ecol. Evol.* **2006**, *6*, 72. [CrossRef]
13. Jalali, N.; Naderi, R.; Shahi-Gharahlar, A.; da Silva, J.A.T. Tissue Culture of *Cyclamen* spp. *Sci. Hortic.* **2012**, *137*, 11–19. [CrossRef]
14. Schwartz-Tzachor, R.; Eisikowitch, D.; Dafni, A. Flower Characteristics and Breeding System of Two Phenological Ecotypes of *Cyclamen persicum* Mill. (Myrsinaceae) in Israel. *Plant Syst. Evol.* **2008**, *274*, 127–134. [CrossRef]
15. Terakawa, T.; Yamamura, T.; Murayama, T. Improvement of Regeneration and Transformation Systems for *Cyclamen persicum* Using Somatic Embryo Culture. *Plant Biotechnol.* **2008**, *25*, 77–80. [CrossRef]
16. Pavlíček, T.; Bureš, P.; Horová, L.; Raskina, O.; Nevo, E. Genome Size Microscale Divergence of *Cyclamen persicum* in Evolution Canyon, Israel. *Open Life Sci.* **2008**, *3*, 83–90. [CrossRef]
17. Savona, M.; Ruffoni, B.; Giovannini, A.; Altamura, M.M. *Cyclamen persicum* Mill Cv. "Halios": Somatic Embryogenesis and Phenotypic Analysis of Somatic Embryo-Derived Plants. *Acta Hortic.* **2007**, 91–97. [CrossRef]
18. Bala, M.; Berecici, D. The Behaviour of Some Old *Cyclamen persicum* Varieties in Growing Conditions of a Modern Greenhouse from the Didactic Base of the Faculty of Horticulture and Forestry in Timişoara. *Bull. Univ. Agric. Sci. Vet.* **2010**, *67*, 298–301.
19. Lewis, K.P.; Faust, J.E.; Sparkman, J.D.; Grimes, L.W. The Effect of Daminozide and Chlormequat on the Growth and Flowering of Poinsettia and Pansy. *HortScience* **2004**, *39*, 1315–1318. [CrossRef]

20. Batelja Lodeta, K.; Goreta Ban, S.; Perica, S.; Dumicic, G.; Bucan, L. Response of Poinsettia to Drench Application of Growth Regulators. *J. Food Agric. Environ.* **2010**, *8*, 297–301.
21. Rademacher, W. Plant Growth Regulators: Backgrounds and Uses in Plant Production. *J. Plant Growth Regul.* **2015**, *34*, 845–872. [CrossRef]
22. Bons, H.K.; Kaur, M. Role of Plant Growth Regulators in Improving Fruit Set, Quality and Yield of Fruit Crops: A Review. *J. Hortic. Sci. Biotechnol.* **2020**, *95*, 137–146. [CrossRef]
23. Runkle, E.; Blancard, M.; Olrich, M. Fascination on Poinsettia. Available online: https://www.canr.msu.edu/resources/fascination-on-poinsettia (accessed on 17 February 2022).
24. Hwang, I.; Sheen, J.; Müller, B. Cytokinin Signaling Networks. *Annu. Rev. Plant Biol.* **2012**, *63*, 353–380. [CrossRef]
25. Markovich, O.; Steiner, E.; Kouřil, Š.; Tarkowski, P.; Aharoni, A.; Elbaum, R. Silicon Promotes Cytokinin Biosynthesis and Delays Senescence in *Arabidopsis* and *Sorghum*: Silicon and Cytokinin. *Plant Cell Environ.* **2017**, *40*, 1189–1196. [CrossRef] [PubMed]
26. Waadt, R.; Seller, C.A.; Hsu, P.-K.; Takahashi, Y.; Munemasa, S.; Schroeder, J.I. Plant Hormone Regulation of Abiotic Stress Responses. *Nat. Rev. Mol. Cell Biol.* **2022**, *23*, 680–694. [CrossRef]
27. Massolo, J.F.; Lemoine, M.L.; Chaves, A.R.; Concellón, A.; Vicente, A.R. Benzyl-Aminopurine (BAP) Treatments Delay Cell Wall Degradation and Softening, Improving Quality Maintenance of Refrigerated Summer Squash. *Postharvest Biol. Technol.* **2014**, *93*, 122–129. [CrossRef]
28. Lee, J.W.; Kim, Y.C.; Kim, J.U.; Jo, I.H.; Kim, K.H.; Kim, D.H. Effects of gibberellic acid and alternating temperature on breaking seed dormancy of Panax ginseng CA Meyer. *Korean J. Med. Crop. Sci.* **2016**, *24*, 284–293. [CrossRef]
29. Oh, W.; Kim, K.S. Light Intensity and Temperature Regulate Petiole Elongation by Controlling the Content of and Sensitivity to Gibberellin in *Cyclamen persicum*. *Hortic. Environ. Biotechnol.* **2014**, *55*, 175–182. [CrossRef]
30. Alshakhaly, Z.M.; Qrunfleh, M.M. Effect of Plant Growth Regulators on Flower Development and Quality of Five *Cyclamen persicum* Hybrids. *Acta Hortic.* **2019**, 215–222. [CrossRef]
31. Hedden, P.; Thomas, S.G. Gibberellin Biosynthesis and Its Regulation. *Biochem. J.* **2012**, *444*, 11–25. [CrossRef] [PubMed]
32. An, K.B.; Lee, Y.S.; Son, K.C. Effect of Plant Growth Retardants on Producing High Quality of *Cyclamen*. *Korean J. Hortic. Sci.* **2004**, *22*, 65.
33. Fletcher, R.A.; Gilley, A.; Sankhla, N.; Davis, T.D. Triazoles as Plant Growth Regulators and Stress Protectants. In *Horticultural Reviews*; Janick, J., Ed.; John Wiley & Sons, Inc.: Oxford, UK, 2010; pp. 55–138. ISBN 978-0-470-65077-6.
34. Rostami, S.; Azhdarpoor, A. The Application of Plant Growth Regulators to Improve Phytoremediation of Contaminated Soils: A Review. *Chemosphere* **2019**, *220*, 818–827. [CrossRef]
35. García-Martinez, J.L.; Gil, J. Light Regulation of Gibberellin Biosynthesis and Mode of Action. *J. Plant Growth Regul.* **2001**, *20*, 354–368. [CrossRef]
36. Tan, Z.G.; Qian, Y.L. Light Intensity Affects Gibberellic Acid Content in Kentucky Bluegrass. *HortScience* **2003**, *38*, 113–116. [CrossRef]
37. Nishijima, T. Use of Plant Growth Regulators for Floriculture in Japan. *Sci. Hortic.* **2023**, *309*, 111630. [CrossRef]
38. Niu, G.; Heins, R.; Carlson, W. Using Paclobutrazol to Control Height of Poinsettia 'Freedom'. *HortTechnology* **2002**, *12*, 232–236. [CrossRef]
39. Elisheba, B.P.; Sudghar, R. Growth Manipulation in Ornamental Sunflower (*Helianthus annuus*) Cv. Ring of Fire as a Bedding Plant. *Crop Res.* **2021**, *56*, 30–36. [CrossRef]
40. Cornea-Cipcigan, M.; Pamfil, D.; Sisea, C.R.; Mărgăoan, R. Gibberellic Acid Can Improve Seed Germination and Ornamental Quality of Selected *Cyclamen* Species Grown under Short and Long Days. *Agronomy* **2020**, *10*, 516. [CrossRef]
41. Kentelky, E.; Szekely-Varga, Z.; Bálint, J.; Balog, A. Enhance Growth and Flower Quality of Chrysanthemum Indicum l. with Application of Plant Growth Retardants. *Horticulturae* **2021**, *7*, 532. [CrossRef]
42. Hg, M.; Dt, L.; Dt, B. Effects of Plant Growth Retardants and Pot Sizes on the Height of Potting Ornamental Plants: A Short Review. *J. Hortic.* **2018**, *5*. [CrossRef]
43. Osterc, G.; Mikulic Petkovsek, M.; Stampar, F.; Ravnjak, B.; Bavcon, J. Impact of Specific Environmental Characteristics of the Site of Origin (Shady, Sunny) on Anthocyanin and Flavonol Contents of Replanted Plants at Common *Cyclamen* (*Cyclamen purpurascens* Mill.). *Acta Physiol. Plant* **2017**, *39*, 64. [CrossRef]
44. Csorba, A.B.; Kentelky, E.; Szabó, M.-E.; Jakab, M.; Nyárádi, I.-I.; Bálint, J. Controlling Grey Mold (*Botrytis cinerea*) in Flowering *Cyclamen* Production. *Europ. J. Hortic. Sci.* **2023**, *88*, 1–8. [CrossRef] [PubMed]
45. Shaul, O.; Elad, Y.; Kirshner, B.; Volpin, H.; Zielsin, N. Control of Botrytis Cinerea in Cut Rose Flowers by Gibberellic Acid, Ethylene Inhibitors and Calcium. In *Recent Advances in Botrytis Research*; Verhoeff, K., Malathrakis, N.E., Williamson, B., Eds.; Pudoc Scientific Publishers: Wageningen, The Netherlands, 1992; pp. 257–261.
46. Bosch, E.; Cuquel, F.L.; Tognon, G.B. Physalis Size Reduction for Potted Ornamental Plant Use. *Ciência Agrotecnologia* **2016**, *40*, 555–564. [CrossRef]
47. Wanderley, C.D.S.; de Faria, R.T.; Ventura, M.U.; Vendrame, W. The Effect of Plant Growth Regulators on Height Control in Potted Arundina Graminifolia Orchids (Growth Regulators in Arundina Graminifolia). *Acta Sci. Agron.* **2014**, *36*, 489. [CrossRef]
48. Bañón, S.; Ochoa, J.; Fernández, J.A.; González, A. Plant Growth Retardants for Introduction of Native Reichardia Tingitana. *Acta Hortic.* **2003**, 271–277. [CrossRef]

49. Ravnjak, B.; Bavcon, J.; Osterc, G. Physiological Response of Local Populations of Species *Cyclamen purpurascens* Mill. to Forest Gaps. *Appl. Ecol. Env. Res.* **2019**, *17*, 11489–11508. [CrossRef]
50. Nowak, J. Wplyw roznych preparatow zawierajacych kwas giberelinowy na wzrost i kwitnienie cyklamena i gerbery. *Zesz. Nauk. Inst. Sadow. I Kwiaciarstwa W Skiern.* **2000**, *7*, 259–263.
51. Sahu, J.K.; Tamrakar, S.K.; Lakpale, R.; Tirkey, T. Effect of Planting Geometry and Plant Growth Regulators on Growth and Flowering of Chrysanthemum. *Progress. Hortic.* **2021**, *53*, 105–108. [CrossRef]
52. Malik, S.; Rather, Z.; Wani, M.; Din, A.; Nazki, I. Effect of Growth Regulators on Plant Growth and Flowering in Dahlia (*Dahlia variabilis*) Cv. Charmit. *J. Exp. Agric. Int.* **2017**, *15*, 1–7. [CrossRef]
53. Choudhury, S.; Islam, N.; Sarkar, M.D.; Ali, M.A. Growth and Yield of Summer Tomato as Influenced by Plant Growth Regulators. *Int. J. Sustain. Agric.* **2013**, *5*, 25–28. [CrossRef]

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